SOIL SURVEY OF

Traill County, North Dakota

United States Department of Agriculture
Soil Conservation Service
In cooperation with
North Dakota Agricultural Experiment Station

This is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and agencies of the States, usually the Agricultural Experiment Stations. In some surveys, other Federal and local agencies also contribute. The Soil Conservation Service has leadership for the Federal part of the National Cooperative Soil Survey. In line with Department of Agriculture policies, benefits of this program are available to all who need the information, regardless of race, color, national origin, sex, religion, marital status, or age.

Major fieldwork for this soil survey was completed in the period 1969–72. Soil names and descriptions were approved in 1974. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1972. This survey was made cooperatively by the Soil Conservation Service and the North Dakota Agricultural Experiment Station. It is part of the technical assistance furnished to the East Traill and West Traill Soil Conservation Districts.

Soil maps in this survey may be copied without permission, but any enlargement of these maps could cause misunderstanding of the detail of mapping and result in erroneous interpretations. Enlarged maps do not show small areas of contrasting soils that could have been shown at a larger mapping scale.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms, windbreaks, and wildlife areas; in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for farming, industry, and recreation.

Locating Soils

All the soils of Traill County are shown on the detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbols. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" lists all the soils of the county in alphabetic order by map symbol and gives the windbreak suitability group of each. It also shows the page where each soil is described and the page for the capability unit in which the soil has been placed.

Individual colored maps showing the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and the information in the text. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Farmers and those who work with farmers can learn about use and management of the soils from the soil descriptions and from the discussions of the capability units and windbreak suitability groups.

Foresters and others can refer to the section "Windbreaks," where the soils of the county are grouped according to their suitability for trees.

Wildlife managers and others can find information about soils and wildlife in the section "Wildlife Habitat."

Community planners and others can read about soil properties that affect the choice of sites for nonindustrial buildings and for recreation areas in the sections "Engineering Uses of the Soils" and "Recreation Facilities."

Engineers and builders can find, under "Engineering Uses of the Soils," tables that contain estimates of soil properties and information about soil features that affect engineering practices.

Scientists and others can read about how the soils formed and how they are classified in the section "Formation and Classification of the Soils."

Newcomers in the area may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the information about the county given in the section "Environmental Factors Affecting Soil Use."

Cover: Windbreaks on the Bearden association protect farmsteads from cold winds and help control soil blowing in winter and spring.

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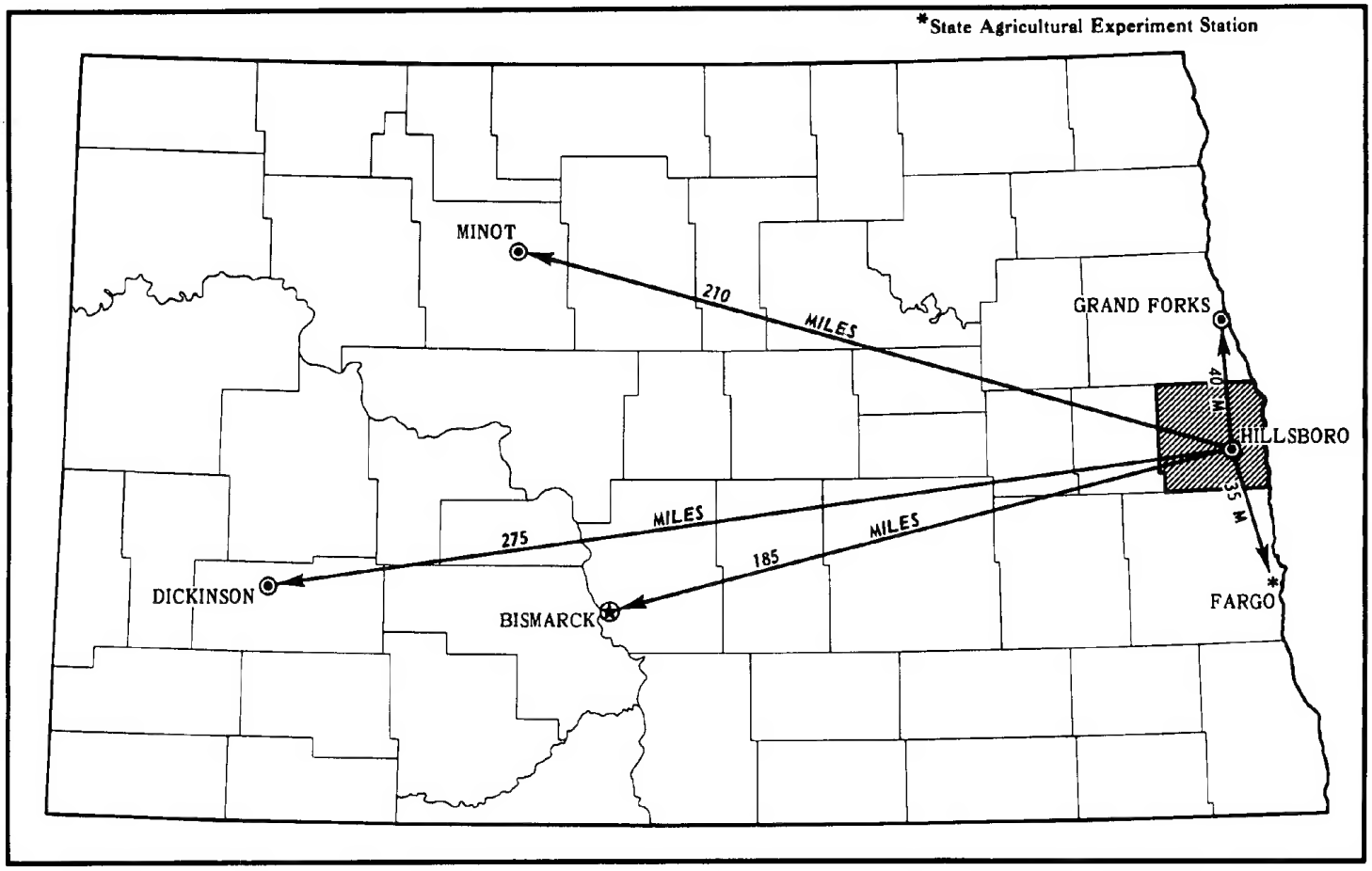

Location of Traill County in North Dakota.

SOIL SURVEY OF TRAILL COUNTY, NORTH DAKOTA

By Norman D. Prochnow, Soil Conservation Service

Fieldwork by Donald G. Thompson, Terry R. Petersen, and Norman D. Prochnow, Soil Conservation Service

United States Department of Agriculture, Soil Conservation Service, in cooperation with the North Dakota Agricultural Experiment Station

TRAILL COUNTY is in the east-central part of North Dakota. It has an area of 551,040 acres. Hillsboro is the county seat.

The county has a subhumid, continental climate that is characterized by cold winters and warm summers. The physiography consists of a nearly level glacial lake plain, except for a glacial till plain in the extreme southwest corner of the county. Beaches, deltas, interbeach areas, bottom lands, and other physiographic features are within areas of the glacial lake plain.

The drainage of the county is in a generally eastward direction toward the north-flowing Red River, which marks the eastern boundary of Traill County.

About 99 percent of the land is farmed, and 90 percent is cultivated. The principal crops are spring wheat, barley, oats, potatoes, sugar beets, and hay. The major livestock enterprise is the raising and feeding of beef cattle.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Traill County, where they are located, and how they can be used.

The soil scientists went into the county knowing they were likely to find many soils they had already seen, and perhaps some they had not. They observed the steepness, length, and shape of slopes, the size and nature of streams, the kinds of crops or native plants, the kinds of rock, and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The *soil series* and the *soil phase* are the categories of soil classification most used in a local survey.

Soils that have profiles almost alike make up a soil series (*8*)[1]. Except for different texture in the surface layer, the major horizons of all the soils of one series are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Fargo and Glyndon, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface layer and in slope, salinity, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Glyndon silt loam, saline, is one of several phases within the Glyndon series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map in the back of this publication was prepared from the aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series or of different phases within one series. Two such kinds of mapping units, soil complexes and undifferentiated groups, are shown on the soil map of Traill County.

A soil complex consists of areas of two or more soils, so intermingled or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant

[1] Italic numbers in parentheses refer to Literature Cited p. 138.

soils, and the pattern and relative proportions are about the same in all areas. The name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Glyndon-Perella silt loams is an example.

An undifferentiated group is made up of two or more soils that could be delineated individually but are shown as one unit because, for the purpose of the soil survey, there is little value in separating them. The pattern and proportion of soils are not uniform. An area shown on the map may be made up of only one of the dominant soils, or of two or more. The name of an undifferentiated group consists of the names of the dominant soils, joined by "and". Bearden and Glyndon silt loams is an example.

In most areas surveyed there are places where the soil material is so wet, so shallow, or so changed by construction that it cannot be classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names, such as "Marsh," which is a land type in Traill County.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soil in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soil. Yields under defined management are estimated for all the soils.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in such a way as to be readily useful to different groups of users, among them farmers, homeowners, and engineers.

On the basis of yield and practice tables and other data, the soil scientists set up trial groups. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others. Then they adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in Traill County. A soil association is a landscape that has a distinctive pattern of soils in defined proportions. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association can occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to locate large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide in managing a watershed, a wooded tract, or a wildlife area or in planning engineering works, recreation facilities, and community developments. It is not a suitable map for planning the management of a farm or field or for selecting a site for a road or building or other structure, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The soil associations in this survey have been grouped into five general kinds of landscapes for broad interpretative purposes. Each of the broad groups and the soil associations in each group are described in the following pages. The terms for texture used in the title for several of the associations refer to the texture of the surface layer of the major soils. For example, in the title of association 1, "moderately fine textured" refers to the texture of the surface layer.

Soils on Glacial Lake Plains

The soil associations in this group consist of nearly level, loamy and clayey soils that formed in loamy and clayey glacial lacustrine deposits and glacial melt-water deposits. Most areas of these soils east of Hillsboro Beach have many small, shallow, scattered depressions. The soils are drained by a system of field drains, road ditches, legal drains, and floodways that empty into the Red, Elm, and Goose Rivers and Buffalo Coulee. The four associations in this group make up 55 percent of the county.

1. Bearden association

Nearly level, deep, somewhat poorly drained, moderately fine textured soils

This association is in concave and convex areas on a nearly level lake plain that ranges from less than 1 foot to 2 feet in elevation (fig. 1). Slopes are nearly level, except along drainageways and on ridges, where they are also generally short.

This association occupies about 18 percent of the county. About 70 percent of the association is Bearden soils and 30 percent minor soils of the Lindaas, Perella, Overly, Colvin, and Great Bend series.

Bearden soils are nearly level and on plane and slightly convex slopes. They are somewhat poorly drained. Their surface layer, typically, is silty clay loam about 14 inches thick. The upper part is black, and the lower part is dark gray and has an accumulation of lime. The next layer is light brownish gray silty clay loam, 7 inches thick, that has an accumulation of lime. The underlying material is light olive brown silty clay loam that is mottled in the lower part.

The poorly drained Lindaas and Perella soils are in shallow depressions and swales. The moderately well drained Overly soils are on low ridges, on breaks to drainageways and streams, and in slightly elevated areas adjacent to breaks of drainageways and streams. The well drained Great Bend soils are on ridges and breaks of drainageways and streams. The poorly drained Colvin soils are in shallow depressions, swales, and seepage areas that are saline in a few places.

Fertility is medium in the Bearden soils, and the organic-matter content and the available water capacity are high.

Growing cash crops is the main enterprise. The soils have a high potential for all crops commonly grown in the county, and nearly all of the acreage is cultivated.

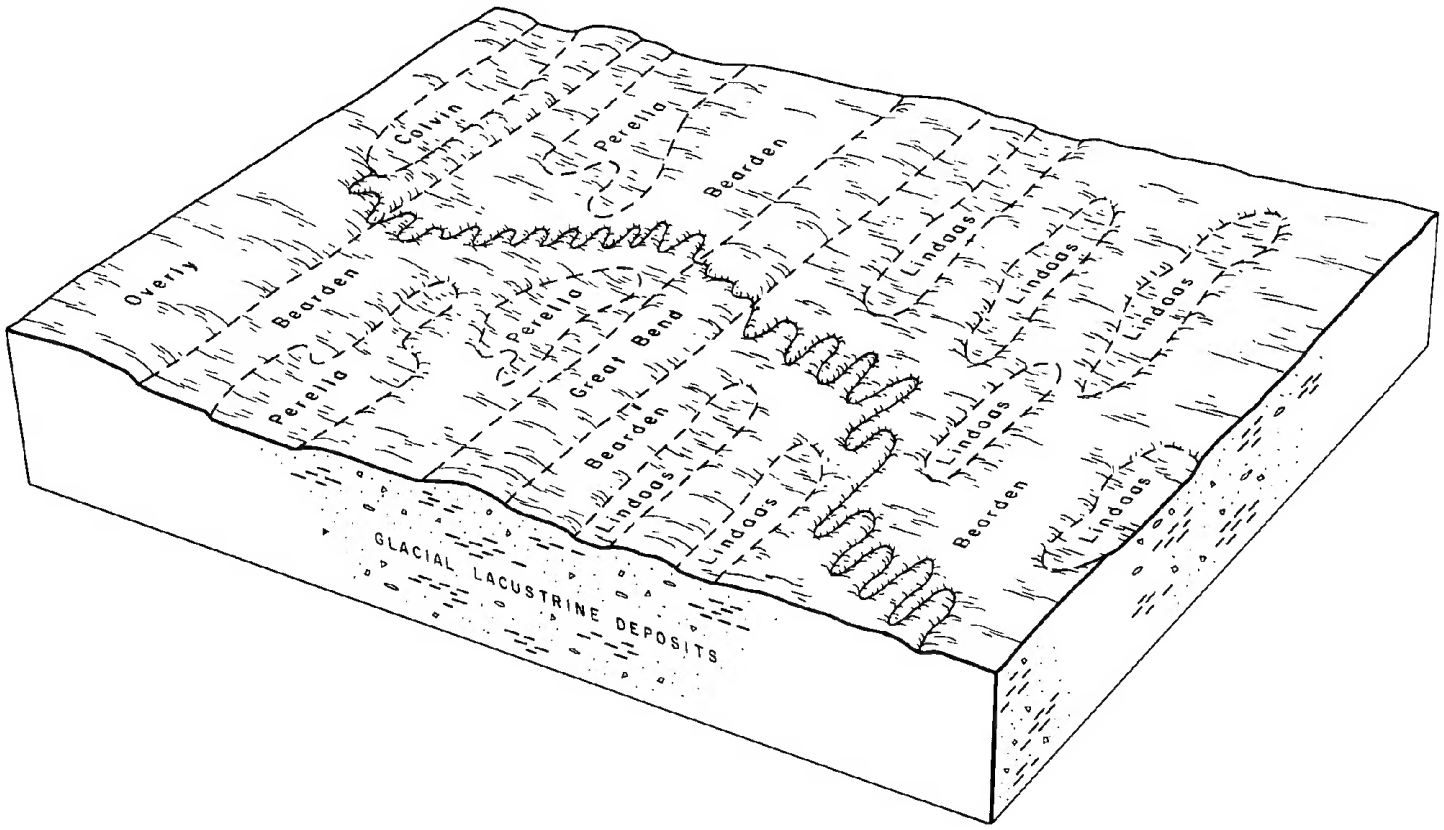

***Figure 1.*—Parent material and position of the soils in the Bearden association.**

Small grain, potatoes, sugar beets, soybeans, sun flowers, legumes, and grasses grow well. The soils in a few small areas are saline; these areas are in grass that is cut for hay or used for pasture.

The main concerns of management are controlling soil blowing, improving drainage, and maintaining and improving tilth and fertility.

2. Fargo-Bearden-Galchutt association

Nearly level, deep, poorly drained and somewhat poorly drained, fine textured and moderately fine textured soils

This association is in concave and convex areas on a nearly level lake plain that ranges from 1 to 3 feet in elevation. Slopes are nearly level, except along drainageways and on ridges, where they are also generally short.

This association occupies about 4 percent of the county. About 30 percent of the association is Fargo soils, 23 percent Bearden soils, 18 percent Galchutt soils, and 29 percent minor soils of the Glyndon, Overly, Wheatville, and Hegne series.

Fargo soils are nearly level and on plane and slightly concave slopes. They are poorly drained. Their surface layer, typically, is black silty clay about 8 inches thick. The subsoil is black, very dark gray, and very dark grayish brown, firm silty clay about 13 inches thick. The underlying material is olive gray, grayish brown, olive, and pale olive silty clay that is mottled in the lower part.

Bearden soils are nearly level and on plane and slightly convex slopes. They are somewhat poorly drained. Their surface layer, typically, is silty clay loam about 14 inches thick. The upper part is black, and the lower part is dark gray and has an accumulation of lime. The next layer is light brownish gray silty clay loam, 7 inches thick, that has an accumulation of lime. The underlying material is light olive brown silty clay loam that is mottled in the lower part.

Galchutt soils are nearly level and on plane and slightly concave slopes. They are somewhat poorly drained. Their surface layer, typically, is black silty clay loam about 16 inches thick. The subsurface layer is very dark grayish brown silt loam, 8 inches thick, that is mottled in the lower part. The subsoil is dark clay about 12 inches thick. The underlying material is olive gray clay.

The somewhat poorly drained, medium textured Glyndon and Wheatville soils are in broad, flat areas. The moderately well drained Overly soils are on slightly elevated positions and in areas adjacent to breaks of drainageways and streams. The poorly drained Hegne soils are in slightly convex areas of the glacial lake plain.

The organic-matter content and the available water capacity are high in all the soils. Fertility is medium in Bearden soils and high in Fargo and Galchutt soils.

Growing cash crops is the main enterprise. The soils have a high potential for nearly all crops commonly grown in the county, and nearly all of this association

is cultivated. Small grain, sugar beets, flax, potatoes, sunflowers, legumes, and grasses grow well. A few small areas are in grass that is cut for hay or used for pasture.

The main concerns of management are controlling soil blowing, improving drainage, and maintaining and improving tilth and fertility.

3. *Fargo-Hegne association*

Nearly level, deep, poorly drained, fine textured soils

This association is in concave and convex areas on a level lake plain that ranges from less than 1 foot to 2 feet in elevation (fig. 2). Slopes are nearly level, except along drainageways and on ridges, where they are also generally short.

This association occupies about 29 percent of the county. About 60 percent of the association is Fargo soils, 22 percent Hegne soils, and 18 percent minor soils of the Enloe, Nutley, Cashel, Wahpeton, and Dovray series.

Fargo soils are nearly level and on plane and slightly concave slopes. They are poorly drained. Their surface layer, typically, is black silty clay about 8 inches thick. The subsoil is black, very dark gray, and very dark grayish brown, firm silty clay about 13 inches thick. The underlying material is olive gray, grayish brown, olive, and pale olive silty clay that is mottled in the lower part.

Hegne soils are nearly level and on slightly convex slopes. They are poorly drained. Their surface layer, typically, is very dark gray silty clay about 9 inches thick. The next layer is light olive gray and olive gray silty clay, 18 inches thick, that has an accumulation of lime and is mottled in the lower part. The underlying material is mottled, olive gray silty clay.

The poorly drained Enloe soils are in shallow depressions on the glacial lake plain. The well drained Nutley soils are on beaches, in slightly elevated areas adjacent to drainageways and streams, and on breaks to drainageways and streams. The somewhat poorly drained Cashel soils are on flood plains along streams. The moderately well drained Wahpeton soils are on low levees and terraces on bottom lands along streams. The poorly drained and very poorly drained Dovray soils are in shallow to deep depressions, swales, and drainageways on the glacial lake plain.

The organic-matter content and the available water capacity are high in all of the soils. Fertility is high in Fargo soils and moderate in Hegne soils.

Growing cash crops is the main enterprise. The soils have a high potential for nearly all crops commonly grown in the county, and nearly all of this association is cultivated. Small grain, sugar beets, flax, sunflowers, legumes, and grasses grow well. A few small areas on breaks and on bottom lands along streams are in grass, and some are in pasture.

The main concerns of management are controlling soil blowing, improving drainage, and maintaining and improving tilth and fertility.

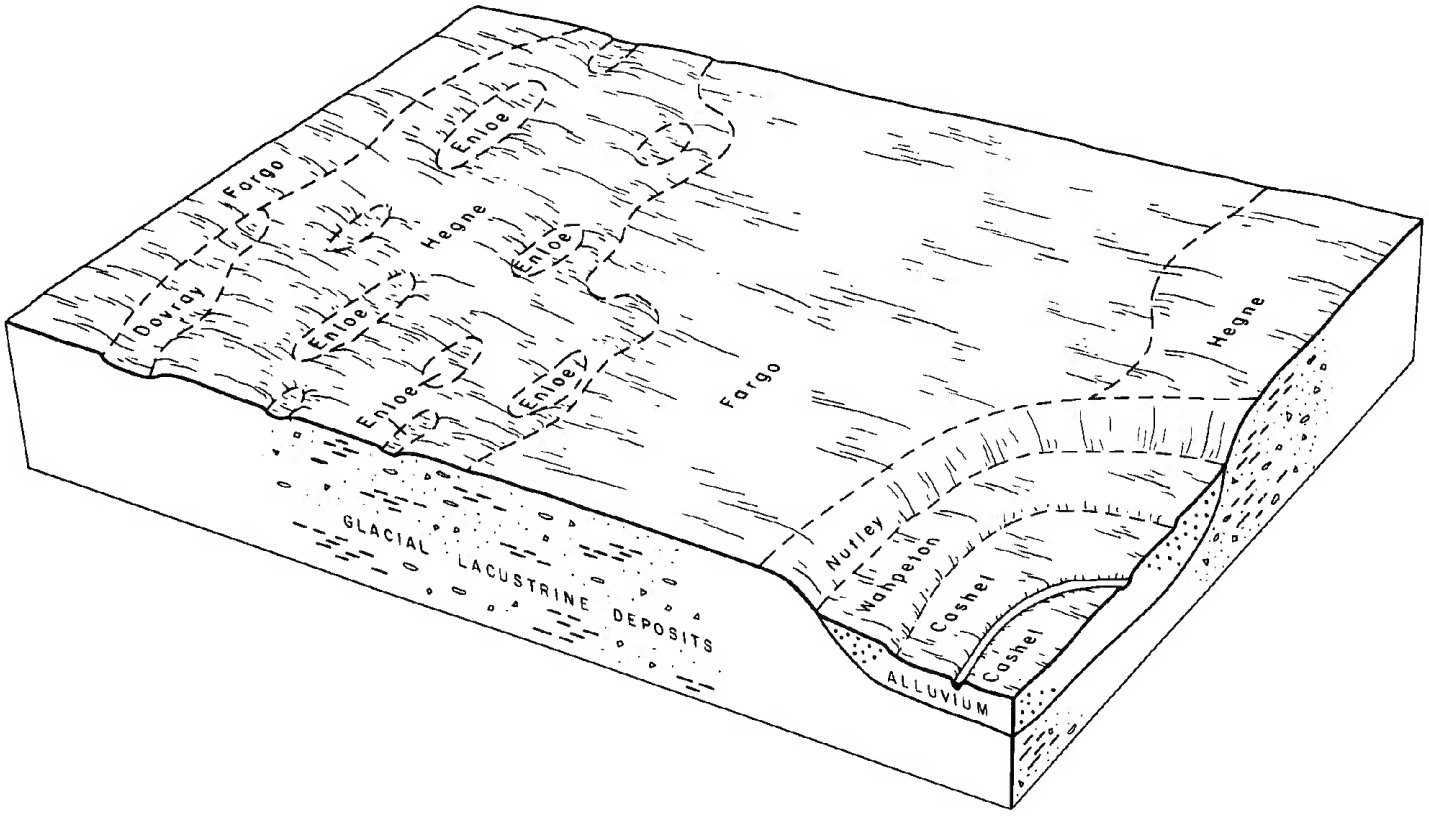

Figure 2.—Parent material and position of the soils in the Fargo-Hegne association.

4. *Overly-Beotia-Bearden association*

Nearly level, deep, well drained to somewhat poorly drained, moderately fine textured and medium textured soils

This association is in plane, concave, and convex areas on a level lake plain that ranges from 1 to 3 feet in elevation (fig. 3). Slopes are nearly level, except along drainageways and on ridges, where they are also generally short.

This association occupies about 4 percent of the county. About 55 percent of the association is Overly soils, 18 percent Beotia soils, 12 percent Bearden soils, and 15 percent minor soils of the Fairdale, Great Bend, and Colvin series.

Overly soils are nearly level and on plane and slightly concave slopes. They are moderately well drained. Their surface layer, typically, is black silty clay loam about 12 inches thick. The subsoil is very dark grayish brown silty clay loam about 10 inches thick. The underlying material is silty clay loam. The upper part is light yellowish brown and has an accumulation of lime. The lower part is mottled and light olive brown.

Beotia soils are nearly level and are on plane and slightly convex slopes. They are well drained. Their surface layer, typically, is black silt loam about 12 inches thick. The subsoil is very dark grayish brown silt loam about 11 inches thick. The next layer is light brownish gray silt loam about 6 inches thick. The underlying material is light olive brown silt loam that is mottled in the lower part.

Bearden soils are nearly level and are on slightly convex slopes. They are somewhat poorly drained. Their surface layer, typically, is silty clay loam about 14 inches thick. The upper part is black, and the lower part is dark gray and has an accumulation of lime. The layer below that is light brownish gray silty clay loam, 7 inches thick, that has an accumulation of lime. The underlying material is light olive brown silty clay loam that is mottled in the lower part.

The moderately well drained Fairdale soils are on flood plains along streams. The well drained Great Bend soils are on ridges and breaks of drainageways and streams. The poorly drained Colvin soils are in shallow depressions, swales, and seepage areas on the glacial lake plain.

The organic-matter content and the available water capacity are high in all of the soils. Fertility is medium in Bearden soils and high in Overly and Beotia soils.

Growing cash crops is the main enterprise. The soils have a high potential for all crops commonly grown in the county, and nearly all of this association is used for cultivated crops. Small grain, potatoes, sugar beets, sunflowers, soybeans, legumes, and grasses grow well on these soils. A few areas along streams are in native woodland, and a few areas are in grass that is cut for hay or used for pasture.

The main concerns of management are maintain-

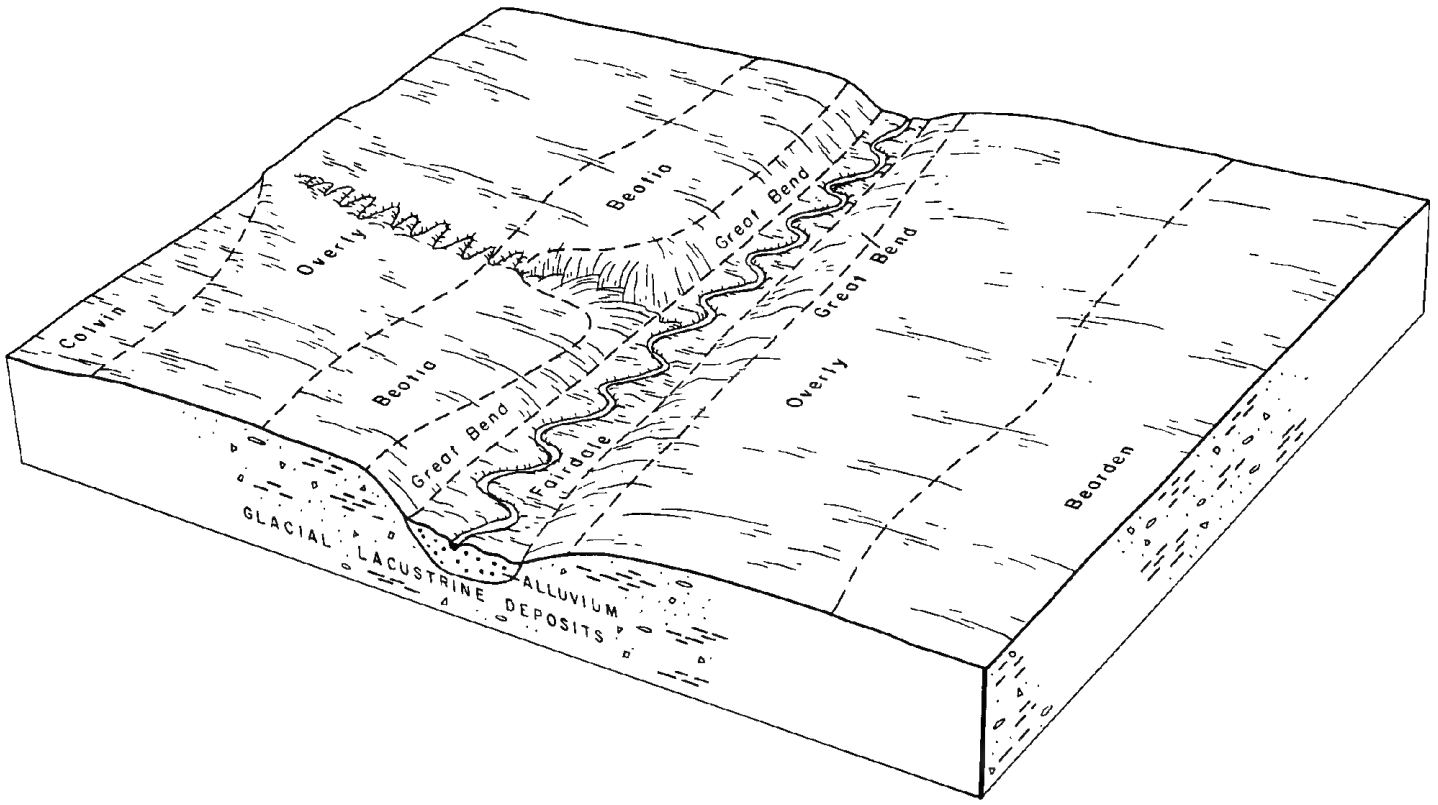

Figure 3.—Parent material and position of the soils in the Overly-Beotia-Bearden association.

ing tilth and fertility, controlling soil blowing, and improving drainage.

Soils on Deltas and Beaches

The soil associations in this group consist of nearly level to sloping, sandy and loamy soils that formed in sandy and loamy glacial melt-water deposits and glacial lacustrine deposits. They are crossed by low, narrow beaches that extend in a north-south direction. The soils are drained by a system of natural drains, field drains, road ditches, and legal drains that empty into the Red, Elm, and Goose Rivers and Buffalo Coulee. The five associations in this group make up 29 percent of the county.

5. *Arvilla-Wyndmere-Embden association*

Nearly level to sloping, shallow and moderately deep over sand and gravel and deep, somewhat excessively drained to somewhat poorly drained, moderately coarse textured soils

This association is in concave and convex areas on nearly level deltas and beaches that range from 1 to 5 feet in elevation. Some beaches are gently sloping and sloping, convex ridges 5 to 15 feet high. Slopes are mostly nearly level.

This association occupies about 2 percent of the county. About 34 percent of the association is Arvilla soils, 23 percent Wyndmere soils, 12 percent Embden soils, and 31 percent minor soils of the Divide, Borup, Hecla, and Sioux series.

Arvilla soils are nearly level to sloping and on beaches that have convex slopes. They are somewhat excessively drained. Their surface layer, typically, is black sandy loam about 11 inches thick. The subsoil is very dark grayish brown sandy loam about 6 inches thick. The underlying material is grayish brown and olive brown sand and gravel.

Wyndmere soils are nearly level and on plane and slightly convex slopes. They are somewhat poorly drained. Their surface layer, typically, is fine sandy loam about 14 inches thick. The upper part is black, and the lower part is very dark gray and has an accumulation of lime. The next layer is gray and light brownish gray fine sandy loam, 13 inches thick, that has an accumulation of lime. The underlying material is light olive brown and olive gray fine sandy loam that is mottled in the lower part.

Embden soils are nearly level to gently sloping and are on plane and slightly convex slopes. They are moderately well drained. Their surface layer, typically, is black fine sandy loam about 19 inches thick. The subsoil is very dark grayish brown fine sandy loam about 8 inches thick. The underlying material is mottled, dark grayish brown and olive brown fine sandy loam.

The somewhat poorly drained Divide soils are on low beaches that have plane and slightly convex slopes. The poorly drained Borup soils are in shallow depressions, swales, and seepage areas of the delta. The moderately well drained Hecla soils are on nearly level to gently sloping beaches and breaks to drainageways and streams. The excessively drained Sioux soils are on nearly level to sloping beaches that have convex slopes.

The organic-matter content is high in all the soils. Fertility is medium in Arvilla and Wyndmere soils and high in Embden soils. The available water capacity is low in Arvilla soils and moderate in Wyndmere and Embden soils.

Growing cash crops and raising beef cattle are the main enterprises. The soils have a potential for most crops commonly grown in the county, and most of this association is used for cultivated crops. Small grain, pinto beans, sunflowers, and grasses grow well on all the soils, and potatoes grow well on Wyndmere and Embden soils. Some areas are in grass that is cut for hay or used for pasture or wildlife habitat. A few areas are mined for sand and gravel.

The main concerns of management are controlling soil blowing and water erosion, conserving moisture, maintaining and improving fertility and organic-matter content, and improving drainage.

6. *Gardena-Overly association*

Nearly level to sloping, deep, moderately well drained, medium textured and moderately fine textured soils

This association is in concave and convex areas on a level delta where the difference in elevation is 1 to 3 feet. Slopes are nearly level, except on breaks to drainageways and streams, where they are also generally short.

This association occupies about 2 percent of the county. About 68 percent of the association is Gardena soils, 11 percent Overly soils, and 21 percent minor soils of the Beotia, Galchutt, Glyndon, and Lankin series.

Gardena soils are nearly level to sloping and on plane and slightly convex slopes. They are moderately well drained. Their surface layer, typically, is black silt loam about 15 inches thick. The subsoil is very dark gray and very dark grayish brown silt loam about 17 inches thick. The underlying material is mottled, light olive brown silt loam.

Overly soils are nearly level to gently sloping and on plane and slightly concave slopes. They are moderately well drained. Their surface layer, typically, is black silty clay loam about 12 inches thick. The subsoil is very dark grayish brown silty clay loam about 10 inches thick. The underlying material is silty clay loam. The upper part is light yellowish brown and has an accumulation of lime. The lower part is mottled and light olive brown.

The well drained Beotia soils are on deltas that have plane and slightly convex slopes. The somewhat poorly drained Galchutt soils are on plane and slightly concave slopes. The somewhat poorly drained Glyndon soils and the moderately well drained Lankin soils are on deltas that have plane and slightly convex slopes.

Fertility, organic-matter content, and available water capacity are high in all the soils.

Growing cash crops is the main enterprise. The soils have a high potential for all crops commonly grown in the county, and nearly all of this association is cultivated. Small grain, potatoes, sugar beets, pinto beans, sunflowers, legumes, and grasses grow well on all the soils. A few areas are in grass that is cut for hay or used for pasture.

The main concerns of management are controlling

soil blowing and water erosion and maintaining tilth and fertility.

7. *Glyndon association*

Nearly level, deep, somewhat poorly drained, medium textured soils

This association is in concave and convex areas on a level delta where the difference in elevation is from less than 1 foot to 3 feet (fig. 4). Slopes are nearly level, except along drainageways and on beaches, where they are also generally short.

This association occupies about 16 percent of the county. About 75 percent of the association is Glyndon soils and 25 percent minor soils of the Perella, Borup, Gardena, Wyndmere, Tiffany, and Wheatville series.

Glyndon soils are nearly level and on plane and slightly convex slopes. They are somewhat poorly drained. Their surface layer, typically, is black silt loam about 8 inches thick. The layer below this is dark gray and light brownish gray silt loam, 16 inches thick, that has an accumulation of lime. The underlying material is mottled, grayish brown and light olive brown very fine sandy loam.

The poorly drained Perella soils are in shallow depressions and swales on the delta. The poorly drained Borup soils are in shallow depressions, swales, and seepage areas. The moderately well drained Gardena soils are on beaches and in slightly elevated areas adjacent to breaks of drainageways and streams. The somewhat poorly drained Wyndmere soils are on low, broad beaches and in areas on the deltas that have plane and convex slopes. The poorly drained Tiffany soils are in shallow depressions and swales. The somewhat poorly drained Wheatville soils are on plane and slightly convex delta slopes.

Fertility is medium, and the organic-matter content and the available water capacity are high.

Growing cash crops is the main enterprise. The soils have a high potential for nearly all crops commonly grown in the county, and nearly all of the acreage is cultivated. Small grain, potatoes, sugar beets, pinto beans, sunflowers, legumes, and grasses grow well. A few areas are in grass that is used for pasture, cut for hay, or used for wildlife habitat.

The main concerns of management are controlling soil blowing, improving drainage, and maintaining and improving fertility.

8. *Hecla-Arveson association*

Nearly level to gently sloping, deep, moderately well drained and poorly drained, coarse textured and medium textured soils

This association is in concave and convex areas on nearly level deltas and beaches where the difference in elevation is 1 to 5 feet (fig. 5). Some beaches occur as gently sloping, convex ridges 5 to 10 feet high. Slopes are mostly nearly level.

This association occupies about 3 percent of the

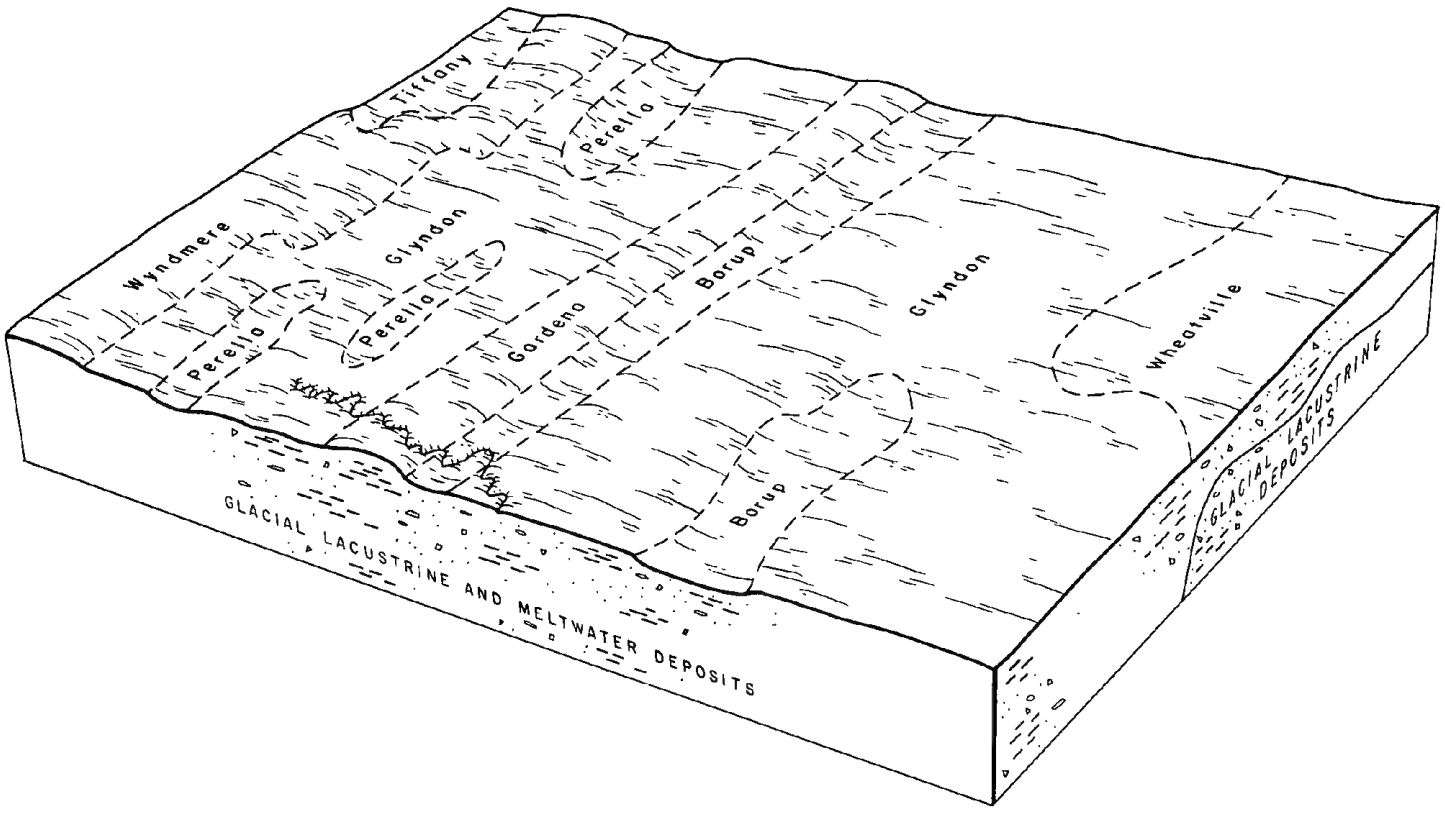

Figure 4.—Parent material and position of the soils in the Glyndon association.

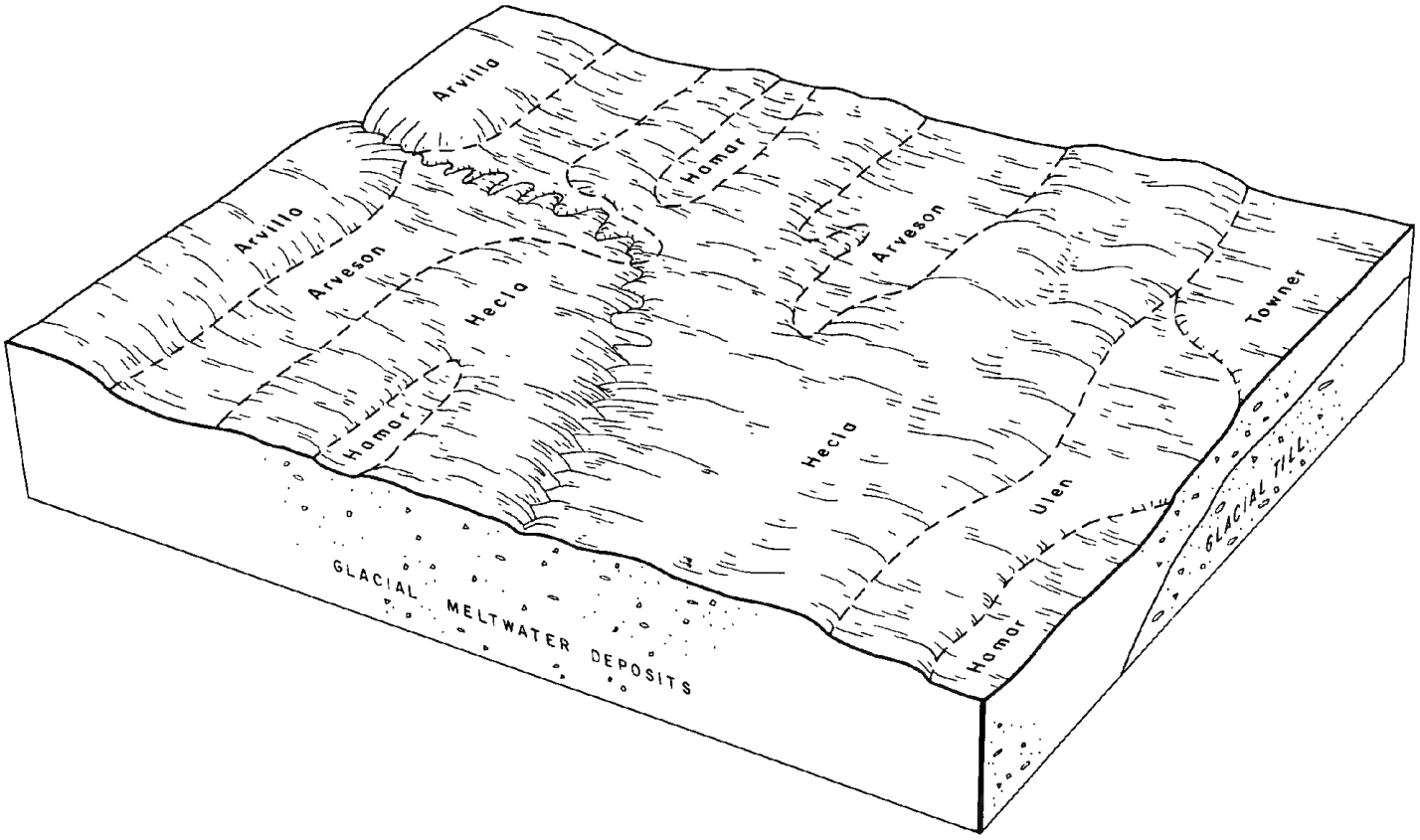

Figure 5.—**Parent material and position of the soils in the Hecla-Arveson association.**

county. About 60 percent of the association is Hecla soils, 19 percent Arveson soils, and 21 percent minor soils of the Towner, Hamar, Ulen, and Arvilla series.

Hecla soils are nearly level to gently sloping and on plane and convex slopes. They are moderately well drained. Their surface layer, typically, is black loamy fine sand about 14 inches thick. The subsoil is very dark grayish brown loamy fine sand about 6 inches thick. The underlying material is dark grayish brown and grayish brown fine sand that is mottled in the lower part.

Arveson soils are nearly level and poorly drained. They are in shallow depressions, swales, and seepage areas. Their surface layer, typically, is very dark gray loam about 10 inches thick. The next layer is mottled, dark gray and gray fine sandy loam, 22 inches thick, that has an accumulation of lime. The underlying material is mottled, gray, dark brown, dark grayish brown, dark yellowish brown, and olive gray loamy fine sand and fine sand.

The moderately well drained Towner soils cover broad areas of the deltas. The poorly drained Hamar soils are in slight depressions and swales on deltas. The somewhat poorly drained Ulen soils are on deltas that have plane and slightly convex slopes. The somewhat excessively drained Arvilla soils are on beaches that have convex slopes.

Fertility is medium, and the organic-matter content is high in all the soils. The available water capacity is low in Hecla soils and moderate in Arveson soils.

Growing cash crops and raising beef cattle are the main farm enterprises. Nearly all of the soils have a potential for most crops commonly grown in the county, and most of this association is used for cultivated crops. Small grain, flax, pinto beans, soybeans, sunflowers, and grasses grow well on these soils. Some areas are in grass that is used for pasture, cut for hay, or used for wildlife habitat.

The main concerns of management are controlling soil blowing, improving drainage, maintaining and improving fertility, and conserving moisture.

9. *Wyndmere-Embden association*

Nearly level, deep, somewhat poorly drained and moderately well drained, moderately coarse textured soils

This association is on concave and convex delta areas where the difference in elevation is 1 to 3 feet. Slopes are nearly level, except along drainageways and on ridges, where they are also generally short.

This association occupies about 6 percent of the county. About 40 percent of the association is Wyndmere soils, 32 percent Embden soils, and 28 percent minor soils of the Egeland, Tiffany, Swenoda, Hecla, and Borup series.

Wyndmere soils are nearly level and on plane and slightly convex slopes. They are somewhat poorly drained. Their surface layer, typically, is fine sandy

loam about 14 inches thick. The upper part is black, and the lower part is very dark gray and has an accumulation of lime. The next layer is gray and light brownish gray fine sandy loam, 13 inches thick, that has an accumulation of lime. The underlying material is light olive brown and olive gray fine sandy loam that is mottled in the lower part.

Embden soils are nearly level and on plane and slightly convex slopes. They are moderately well drained. Their surface layer, typically, is black fine sandy loam about 19 inches thick. The subsoil is very dark grayish brown fine sandy loam about 8 inches thick. The underlying material is mottled, dark grayish brown and olive brown fine sandy loam.

The well drained Egeland soils are on beaches and breaks of drainageways and streams. The poorly drained Tiffany soils are in shallow depressions and swales. The moderately well drained Swenoda soils are on deltas that have plane and slightly convex slopes. The moderately well drained Hecla soils are on beaches and breaks of drainageways and streams. The poorly drained Borup soils are in shallow depressions, swales, and seepage areas on the delta.

The organic-matter content is high, and the available water capacity is moderate in all the soils. Fertility is medium in Wyndmere soils and high in Embden soils.

Growing cash crops is the main enterprise. The soils have a potential for nearly all crops commonly grown in the county, and nearly all of this association is used for cultivated crops. Small grain, potatoes, pinto beans, soybeans, sunflowers, and grasses grow well on these soils. A few areas are in grass that is cut for hay or used for pasture.

The main concerns of management are controlling soil blowing, conserving moisture, maintaining and improving fertility, and improving drainage.

Soils on Interbeach Areas

The soil associations in this group consist of nearly level, loamy and clayey soils that formed in glacial melt–water deposits, glacial lacustrine deposits, and water-worked glacial till. In some places, the interbeach areas have many small, scattered, distinct depressions. The slopes are nearly level, except on beaches and breaks of drainageways and streams. Narrow to broad and nearly level to sloping beaches cross the associations in a north-south direction. The sloping beaches generally are narrow. The soils are drained by a system of natural drains, field drains, road ditches, legal drains, and floodways that empty into the Buffalo Coulee and the Goose and Elm Rivers. The three associations in this group make up 12 percent of the county.

10. Bohnsack-Lankin association

Nearly level, deep, somewhat poorly drained and moderately well drained, medium textured soils

This association is in concave and convex areas between nearly level beaches where the difference in elevation is 1 to 3 feet. Some beaches occur as gently sloping to sloping, convex ridges 5 to 15 feet high. Slopes are mostly nearly level.

This association occupies about 3 percent of the county. About 50 percent of the association is Bohnsack soils, 23 percent Lankin soils, and 27 percent minor soils of the Emrick, Gilby, Tiffany, and Glyndon series.

Bohnsack soils are nearly level and on plane and slightly convex slopes. They are somewhat poorly drained. Their surface layer, typically, is black loam about 8 inches thick. The next layer is grayish brown loam, 16 inches thick, that has an accumulation of lime. The underlying material is olive brown and light olive brown silt loam that is mottled in the lower part.

Lankin soils are nearly level and on plane and slightly convex slopes. They are moderately well drained. Their surface layer, typically, is black loam about 10 inches thick. The subsoil is very dark gray and dark grayish brown loam and clay loam, 20 inches thick, that is mottled in the lower part. The underlying material is mottled, light brownish gray and grayish brown clay loam.

The moderately well drained Emrick soils are between beaches and on plane and slightly concave slopes. The somewhat poorly drained Gilby soils and the somewhat poorly drained Glyndon soils are between beaches that have plane and slightly convex slopes. The poorly drained Tiffany soils are in shallow depressions and swales.

The available water capacity and the organic-matter content are high in all the soils. Fertility is medium in Bohnsack soils and high in Lankin and Emrick soils.

Growing cash crops is the main enterprise. The soils have a potential for most crops commonly grown in the county, and nearly all of this association is used for crops. Small grain, flax, pinto beans, soybeans, sunflowers, legumes, and grasses grow well on all the soils. A few areas are in grass that is cut for hay or used for pasture.

The main concerns of management are controlling soil blowing, improving drainage, removing stones, and maintaining and improving fertility and organic-matter content.

11. Doran-Viking association

Nearly level, deep, somewhat poorly drained and poorly drained, moderately fine textured and fine textured soils

This association is in concave and convex areas between nearly level beaches where the difference in elevation is less than 1 foot to 3 feet. Slopes are nearly level, except along drainageways and streams and on beaches, where they are also generally short.

This association occupies about 1 percent of the county. About 63 percent of the association is Doran soils, 28 percent Viking soils, and 9 percent minor soils of the Lankin, Bohnsack, and Emrick series.

Doran soils are nearly level and on plane and slightly concave slopes. They are somewhat poorly drained. Their surface layer, typically, is black clay loam about 8 inches thick. The subsoil is very dark grayish brown and dark grayish brown clay and clay loam about 13 inches thick. The underlying material is mottled, light brownish gray, light yellowish brown, and light olive brown clay loam and loam.

Viking soils are nearly level and on plane and slightly

concave slopes. They are poorly drained. Their surface layer, typically, is black clay about 7 inches thick. The subsoil is very dark gray and dark gray clay about 18 inches thick. The underlying material is mottled, olive gray clay.

The moderately well drained Lankin soils and the somewhat poorly drained Bohnsack soils are between beaches that have plane and slightly convex slopes. The moderately well drained Emrick soils are between beaches that have plane and slightly concave slopes.

Fertility, organic-matter content, and available water capacity are high.

Growing cash crops is the main enterprise. The soils have a potential for most crops commonly grown in the county, and nearly all of this association is cultivated. Small grain, flax, sunflowers, legumes, and grasses grow well on all the soils. A few small areas are in grass.

The main concerns of management are controlling soil blowing, improving drainage, removing stones, and maintaining tilth and fertility.

12. Hamerly-Gilby-Tonka association

Nearly level, deep, somewhat poorly drained and poorly drained, moderately fine textured and medium textured soils

This association is in concave and convex areas between beaches where the difference in elevation is 1 to 5 feet. Some beaches occur as gently sloping ridges 4 to 10 feet high, but slopes are mostly nearly level. The gentle slopes generally are short.

This association occupies about 8 percent of the county. About 26 percent of the association is Hamerly soils, 23 percent Gilby soils, 22 percent Tonka soils, and 29 percent minor soils of the Doran, Vallers, Lankin, Divide, and Bohnsack series.

Hamerly soils are nearly level and on slightly convex slopes. They are somewhat poorly drained. Their surface layer, typically, is black clay loam about 7 inches thick. The next layer is very dark gray and dark gray clay loam, 8 inches thick, that has an accumulation of lime. The underlying material is dark grayish brown and olive gray clay loam.

Gilby soils are nearly level and on plane and slightly convex slopes. They are somewhat poorly drained. Their surface layer, typically, is black loam about 8 inches thick. The next layer is gray and grayish brown loam, 13 inches thick, that has an accumulation of lime and is mottled in the lower part. The underlying material is mottled, grayish brown, light olive gray, and pale olive loam and clay loam.

Tonka soils are nearly level and poorly drained. They are in shallow, closed depressions. Their surface layer, typically, is black silt loam about 8 inches thick. The subsurface layer is mottled, dark grayish brown loam 11 inches thick. The subsoil is mottled, olive gray clay 17 inches thick. The underlying material is mottled, dark grayish brown clay loam.

The somewhat poorly drained Doran soils are between beaches that have plane and slightly concave slopes. The poorly drained Vallers soils, the moderately well drained Lankin soils, and the somewhat poorly drained Bohnsack soils are between beaches that have plane and slightly convex slopes. The somewhat poorly drained Divide soils are on low beaches that have plane and slightly convex slopes.

The organic-matter content and the available water capacity are high in all the soils. Fertility is medium in Hamerly and Gilby soils and high in Tonka soils.

Growing cash crops and raising beef cattle are the main enterprises. The soils have a potential for most crops commonly grown in the county, and most of this association is used for cultivated crops. Small grain, flax, sunflowers, legumes, and grasses grow well on these soils. Some areas are in grass that is cut for hay or used for pasture, and a few undrained areas are used for wildlife habitat.

The main concerns of management are controlling soil blowing, improving drainage, removing stones, and maintaining and improving tilth and fertility.

Soils on Breaks and Bottom Lands

The soil association in this group consists of nearly level to moderately steep, loamy and clayey soils on bottom lands and breaks. These soils formed in glacial lacustrine deposits and in alluvium deposited by streams. The soils on the bottom lands are nearly level, except along abandoned stream channels and streambanks. The soils on the breaks are nearly level to moderately steep. The steeper slopes generally are short. The soils on bottom lands are subject to flooding by streams. The one association in this group makes up 3 percent of the county.

13. La Prairie-Nutley-Fairdale association

Nearly level to moderately steep, deep, moderately well drained and well drained, medium textured and fine textured soils

This association consists of concave and convex bottom lands and convex breaks. Slopes are nearly level in most places on the bottom lands, except in abandoned stream channels. Slopes range from nearly level to moderately steep on the breaks where the difference in elevation is 30 to 60 feet.

This association occupies about 3 percent of the county. About 20 percent of the association is La Prairie soils, 20 percent Nutley soils, 18 percent Fairdale soils, and 42 percent minor soils of the Great Bend, Zell, and Overly series.

La Prairie soils are nearly level and moderately well drained. Their surface layer, typically, is black and very dark gray silt loam about 31 inches thick. The next layer is dark grayish brown silt loam about 13 inches thick. The underlying material is black and dark grayish brown silt loam.

Nutley soils are nearly level to moderately steep and well drained. Their surface layer, typically, is black silty clay about 9 inches thick. The subsoil is dark grayish brown silty clay about 15 inches thick. The underlying material is mottled, grayish brown and olive silty clay.

Fairdale soils are nearly level and moderately well drained. Their surface layer, typically, is very dark grayish brown silt loam about 10 inches thick. The next layer is dark grayish brown silt loam about 27 inches thick. Below this is a buried layer of very dark gray

silt loam about 5 inches thick. The underlying material is dark grayish brown silt loam.

The well drained Great Bend soils are on gently sloping to strongly sloping breaks to drainageways and bottom lands along streams. The well drained Zell soils are on strongly sloping to moderately steep breaks to drainageways and bottom lands along streams. The moderately well drained Overly soils are nearly level in the slightly elevated areas adjacent to breaks and gently sloping on the breaks to drainageways and bottom lands along streams.

The available water capacity is high in all the soils. The organic-matter content is moderate in Nutley and Fairdale soils and high in La Prairie soils. Fertility is medium in Nutley soils and high in the Fairdale and La Prairie soils.

Growing cash crops is the main enterprise. The soils on bottom lands have a high potential for all cultivated crops commonly grown in the county, and about 70 percent of this association is used for cultivated crops. Small grain, flax, sugar beets, potatoes, pinto beans, soybeans, sunflowers, and grasses grow well on all soils of this association, except on the steeper breaks. Areas along the rivers are in native woodland and are used for pasture or wildlife habitat. Some areas on the steeper breaks are in native woodland or grass and are used for pasture or wildlife habitat.

The main concerns of management are controlling water erosion and flooding from streams and maintaining and improving tilth and fertility.

Soils on Glacial Till Plains

The soil association in this group consists of nearly level to rolling, loamy soils that formed in loamy water-worked glacial till. Slopes are mostly nearly level and undulating, except along drainageways and around sloughs. Slopes generally are short. In most areas the water runs off in natural drainageways into sloughs and streams. The one association in this group makes up 1 percent of the county.

14. Emrick-Heimdal association

Nearly level to rolling, deep, moderately well drained and well drained, medium textured soils

This association is in swells and swales on undulating ground moraine where the difference in elevation is about 5 to 20 feet. Slopes are mostly nearly level and undulating, except around sloughs and along drainageways where they are also generally short.

This association occupies about 1 percent of the county. About 50 percent of the association is Emrick soils, 27 percent Heimdal soils, and 23 percent minor soils of the Renshaw, Egeland, and Esmond series.

Emrick soils are nearly level and undulating and are moderately well drained. Their surface layer, typically, is black loam about 9 inches thick. The subsoil is very dark grayish brown and dark grayish brown loam about 23 inches thick. The underlying material is grayish brown and light olive brown loam that is mottled in the lower part.

Heimdal soils are nearly level to rolling and are well drained. Their surface layer, typically, is black loam about 7 inches thick. The subsoil is dark grayish brown and brown loam about 14 inches thick. The underlying material is light olive brown loam that is mottled in the lower part.

The somewhat excessively drained Renshaw soils are on nearly level ridges. The well drained, gently sloping Egeland soils are on the convex side slopes of the glacial till plain. The well drained Esmond soils are on the steeper convex side slopes of the glacial till plain.

The organic-matter content and the available water capacity are high in all the soils. Fertility is medium in Heimdal soils and high in Emrick soils.

Growing cash crops is the main enterprise. The soils have potential for most crops commonly grown in the county, and most of this association is used for cultivated crops. Small grain, flax, pinto beans, soybeans, sunflowers, and grasses grow well on these soils. A few steep areas and a few undrained, wet areas are used for pasture and wildlife habitat.

The main concerns of management are controlling water erosion, conserving moisture, controlling soil blowing, and maintaining and improving fertility.

Descriptions of the Soils

This section describes the soil series and mapping units in Traill County. Each soil series is described in detail, and then, briefly, each mapping unit in that series. Unless it is specifically mentioned otherwise, it is to be assumed that what is stated about the soil series holds true for the mapping units in that series. Thus, to get full information about any one mapping unit, it is necessary to read both the description of the mapping unit and the description of the soil series to which it belongs.

An important part of the description of each soil series is the soil profile, that is, the sequence of layers from the surface downward to rock or other underlying material. Each series contains two descriptions of this profile. The first is brief and in terms familiar to the layman. The second is much more detailed and is for those who need to make thorough and precise studies of soils. Color terms are for moist soil, unless otherwise stated. The profile described in the series is representative for mapping units in that series. If the profile of a given mapping unit is different from the one described for the series, these differences are stated in describing the mapping unit, or they are differences that are apparent in the name of the mapping unit.

As mentioned in the section "How This Survey Was Made," not all mapping units are members of a soil series. Cut and fill land and Marsh, for example, are miscellaneous land types that do not belong to a soil series, but nevertheless, are listed in alphabetic order along with the soil series.

Preceding the name of each mapping unit is a symbol that identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit and windbreak suitability group in which the mapping unit has been placed. The page for the description of each capability unit is listed in the "Guide to Mapping Units" at the back of this survey.

The acreage and proportionate extent of each map-

ping unit are shown in table 1. Many of the terms used in describing soils can be found in the "Glossary" at the end of this survey, some are defined in the section "How This Survey Was Made," and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (*8*).

Arveson Series

The Arveson series consists of deep, nearly level, poorly drained soils. These soils are in shallow depressions, swales, and seepage areas on the delta and between the beaches. They formed in moderately coarse textured and coarse textured glacial melt-water deposits.

TABLE 1.—*Approximate acreage and proportionate extent of the soils*

Soil	Area	Extent	Soil	Area	Extent
	Acres	*Percent*		*Acres*	*Percent*
Arveson fine sandy loam	330	0.1	Great Bend silty clay loam, 6 to 9 percent slopes	1,520	.3
Arveson loam	3,240	.6	Great Bend silty clay loam, 9 to 15 percent slopes	852	.2
Arvilla sandy loam, 1 to 6 percent slopes	5,194	1.0	Hamar loamy fine sand	782	.1
Bearden silt loam, saline	1,069	.2	Hamerly-Tonka clay loams	17,471	3.2
Bearden silty clay loam	24,145	4.4	Hamerly-Tonka clay loams, saline	2,033	.4
Bearden silty clay loam, clay substratum	4,677	.8	Hecla loamy fine sand, 1 to 3 percent slopes	4,674	.8
Bearden-Lindaas silty clay loams	31,770	5.8	Hecla fine sandy loam, 1 to 3 percent slopes	5,323	1.0
Bearden-Overly silty clay loams	9,232	1.7	Hecla-Maddock sandy loams, 1 to 6 percent slopes	1,613	.3
Bearden-Perella silty clay loams	20,539	3.7	Hegne-Enloe silty clays	29,080	5.3
Bearden and Glyndon silt loams	13,079	2.4	Hegne-Fargo silty clays	8,511	1.5
Beotia silt loam	4,978	.9	Heimdal-Emrick loams, 3 to 6 percent slopes	600	.1
Bohnsack loam	8,428	1.5	Heimdal-Esmond loams, 6 to 9 percent slopes	348	.1
Bohnsack-Tiffany loams	1,274	.2	LaDelle silty clay loam	1,695	.3
Borup silt loam	6,713	1.2	Lamoure silt loam	1,860	.3
Borup silt loam, saline	454	.1	Lankin loam	5,659	1.0
Cashel silty clay, 1 to 3 percent slopes	2,888	.5	La Prairie silt loam	3,631	.7
Cashel silty clay, channeled	813	.1	Ludden silty clay	861	.2
Colvin silt loam	1,909	.3	Marsh	1,235	.2
Colvin silt loam, saline	849	.2	Nahon silt loam	909	.2
Cut and fill land	439	.1	Nutley silty clay, 1 to 3 percent slopes	4,901	.9
Divide loam	2,256	.4	Nutley silty clay, 3 to 6 percent slopes	3,405	.6
Doran clay loam	5,033	.9	Nutley silty clay, 6 to 9 percent slopes	1,727	.3
Dovray silty clay	1,052	.2	Nutley silty clay, 9 to 15 percent slopes	648	.1
Egeland loam, 1 to 3 percent slopes	600	.1	Nutley silty clay, 15 to 25 percent slopes	856	.2
Egeland-Embden fine sandy loams, 1 to 3 percent slopes	2,107	.4	Ojata silty clay loam	550	.1
Egeland-Embden fine sandy loams, 3 to 6 percent slopes	346	.1	Overly silty clay loam	13,733	2.5
Embden fine sandy loam	8,014	1.5	Overly-Fargo complex	2,677	.5
Embden very fine sandy loam	2,330	.4	Overly-Great Bend silty clay loams, 3 to 6 percent slopes	1,602	.3
Emrick loam	2,230	.4	Perella silt loam	1,232	.2
Emrick-Heimdal loams, 1 to 3 percent slopes	835	.2	Playmoor silty clay loam	723	.1
Fairdale silt loam, 1 to 3 percent slopes	4,676	.9	Renshaw loam, 1 to 3 percent slopes	1,492	.3
Fargo silty clay loam	4,933	.9	Rockwell fine sandy loam	742	.1
Fargo silty clay	65,818	11.9	Serden-Maddock loamy sands, 1 to 6 percent slopes	220	(1)
Fargo-Dovray silty clays	3,477	.6	Sioux-Arvilla complex, 1 to 6 percent slopes	1,298	.2
Fargo-Enloe silty clay loams	1,689	.3	Swenoda fine sandy loam	897	.2
Fargo-Enloe silty clays	1,574	.3	Swenoda loam	1,695	.3
Fargo-Hegne silty clays	32,881	6.0	Tiffany loam	929	.2
Fargo-Ryan silty clays	1,046	.2	Tonka silt loam	543	.1
Galchutt-Fargo complex	7,039	1.3	Towner sandy loam, 1 to 3 percent slopes	1,112	.2
Gardena silt loam	9,979	1.8	Ulen fine sandy loam	686	.1
Gardena-Eckman silt loams, 3 to 6 percent slopes	859	.2	Vallers-Doran clay loams	5,232	.9
Gardena-Zell silt loams, 6 to 9 percent slopes	607	.1	Viking clay	2,087	.4
Gilby loam	4,697	.8	Wahpeton silty clay, 1 to 3 percent slopes	1,076	.2
Gilby-Tonka complex	8,922	1.6	Wheatville silt loam	1,481	.3
Gilby-Tonka complex, saline	1,364	.2	Wyndmere fine sandy loam	9,098	1.7
Glyndon silt loam	55,805	10.1	Wyndmere loam	6,297	1.1
Glyndon silt loam, saline	587	.1	Wyndmere loam, saline	408	.1
Glyndon-Perella silt loams	13,728	2.5	Wnydmere-Tiffany fine sandy loams	2,211	.4
Glyndon-Tiffany loams	2,413	.4	Zell silt loam, 9 to 25 percent slopes	1,239	.2
Grano silty clay	269	(1)	Water	582	.1
Gravel pits	807	.1	Total	551,040	100.0
Great Bend silty clay loam, 1 to 3 percent slopes	1,011	.2			

[1] Less than 0.05 percent.

In a representative profile the surface layer is very dark gray fine sandy loam about 10 inches thick. The underlying material, to a depth of 32 inches, is fine sandy loam that has an accumulation of lime. The upper part is dark gray and mottled with dark yellowish brown, and the lower part is gray and mottled with grayish brown. The next 28 inches or more is gray and dark brown loamy fine sand in the upper part, dark grayish brown loamy fine sand that is mottled with yellowish brown in the middle part, and dark yellowish brown and olive gray fine sand in the lower part.

Permeability is moderately rapid, and the available water capacity is moderate. The organic-matter content is high, and fertility is medium. These soils have a high water table 1 to 3 feet below the surface.

In most areas Arveson soils are well suited to farming and if excess water is removed, to trees. Some areas of these soils are used for crops, and some areas are in grass. The limitations for most nonfarm uses are severe.

Representative profile of Arveson fine sandy loam, in a cultivated field, 243 feet north and 246 feet west of the southeast corner of sec. 11, T. 148 N., R. 53 W.

Ap—0 to 8 inches, very dark gray (10YR 3/1) fine sandy loam, dark gray (10YR 4/1) when dry; weak medium granular structure; soft, very friable, slightly sticky and slightly plastic; many roots and pores; slightly effervescent; mildly alkaline; abrupt smooth boundary.

A12—8 to 10 inches, very dark gray (10YR 3/1) fine sandy loam, gray (10YR 5/1) when dry; common medium distinct dark yellowish brown (10YR 4/4) mottles; weak medium granular structure; soft, very friable, slightly sticky and slightly plastic; many roots and pores; slightly effervescent; mildly alkaline; clear wavy boundary.

C1cag—10 to 16 inches, dark gray (2.5Y 4/1) fine sandy loam, white (2.5Y 8/1) when dry; common medium distinct dark yellowish brown (10YR 4/4) mottles; weak coarse prismatic structure; soft, very friable, slightly sticky and slightly plastic; common roots and many pores; violently effervescent; mildly alkaline; gradual wavy boundary.

C2cag—16 to 32 inches, gray (5Y 6/1) fine sandy loam, white (5Y 8/1) when dry; common coarse distinct grayish brown (10Y 5/2) mottles; weak coarse prismatic structure; soft, very friable, slightly sticky and slightly plastic; common roots and many pores; violently effervescent; mildly alkaline; gradual wavy boundary.

C3g—32 to 41 inches, gray (5Y 6/1) and dark brown (10YR 4/3) loamy fine sand, white (5Y 8/1) and light yellowish brown (10YR 6/4) when dry; weak coarse prismatic structure; soft, very friable, slightly sticky and slightly plastic; few roots and many roots and pores; slightly effervescent; mildly alkaline; abrupt smooth boundary.

C4g—41 to 54 inches, dark grayish brown (2.5Y 4/2) loamy fine sand, light brownish gray (2.5Y 6/2) when dry; few fine distinct yellowish brown mottles; single grained; loose, nonsticky and nonplastic; slightly effervescent; mildly alkaline; gradual wavy boundary.

C5—54 to 60 inches, olive gray (5Y 6/2) and dark yellowish brown (10YR 4/4) fine sand, yellowish brown (10YR 5/4) and light gray (5Y 7/2) when dry; single grained; loose, nonsticky and nonplastic; slightly effervescent; mildly alkaline.

The A horizon ranges from 7 to 15 inches in thickness. It is black or very dark gray loam, sandy loam, or fine sandy loam. The lower part of the A horizon has an accumulation of lime in places. The Ccag horizon is dark gray to light olive gray sandy loam or fine sandy loam. It is mildly alkaline or moderately alkaline. The C horizon ranges from loamy fine sand to sand, but it is commonly loamy fine sand and fine sand.

Arveson soils formed in material similar to that in which the Embden, Tiffany, and Wyndmere soils formed. They have a calcareous A horizon and, unlike Embden soils, they lack a B horizon. They have, within 16 inches of the surface, a layer where lime has accumulated, but this layer is lacking in Tiffany soils. They are more poorly drained than Wyndmere soils.

Ar—Arveson fine sandy loam. This soil is in shallow depressions, swales, and seepage areas on the delta and between the beaches. It has the profile described as representative of the series. The surface layer is fine sandy loam in most places, but it is sandy loam in a few areas. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Tiffany fine sandy loam, which makes up not more than 15 percent of this mapping unit. The Tiffany soil is in the deeper part of the depressions and swales.

A water table is near the surface in spring during periods of heavy rainfall. Runoff is very slow. Water ponds in some places for short periods in spring during periods when rainfall is high and when snow melts rapidly. Soil blowing is a severe hazard.

Most areas of this soil are used for crops, but some areas are in grass. This soil is fairly well suited to farming and, if excess water is removed, to trees. Removing excess water, controlling soil blowing, and improving fertility are the main concerns of management. Capability unit IIIew–3; windbreak suitability group 2.

As—Arveson loam. This soil is in shallow depressions, swales, and seepage areas on the delta and between the beaches. It has a profile similar to the one described as representative of the series, but the surface layer is loam. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Tiffany loam, which makes up not more than 9 percent of this mapping unit, and very poorly drained Arveson loam, which makes up not more than 6 percent. The Tiffany soil is on plane or slightly concave places in depressions and swales. Also included are areas of Arveson loam which has a substratum of clay loam, silty clay loam, or silty clay at a depth of 40 to 60 inches and which makes up not more than 5 percent of this mapping unit. Small saline areas, a few small very wet areas, and a few small gumbo spots are indicated on the soil map by an appropriate symbol.

A high water table is near the surface in spring and during periods of heavy rainfall. Runoff is very slow. Water ponds in some places for short periods in spring when rainfall is high and snow melts rapidly. Soil blowing is a moderate hazard.

Some areas of this soil are used for crops, and some are in grass. If excess water is removed, this soil is well suited to farming and, in most places, to trees. Removing excess water, controlling soil blowing, and improving fertility are the main concerns of management. Capability unit IIw–4L; windbreak suitability group 2.

Arvilla Series

The Arvilla series consists of nearly level and gently sloping, somewhat excessively drained soils that are shallow and moderately deep over sand and gravel.

These soils are on beaches on the delta and between the beaches. They formed in a thin layer of moderately coarse textured glacial melt-water deposits over sand and gravel.

In a representative profile the surface layer is black sandy loam about 11 inches thick. The subsoil is very dark grayish brown sandy loam about 6 inches thick. The underlying material is grayish brown and olive brown sand and gravel.

Permeability is moderately rapid in the surface layer and subsoil and very rapid in the underlying material. The available water capacity is low. The organic-matter content is high, and fertility is medium. These soils have a deep water table.

Arvilla soils are fairly well suited to farming and, in most areas, poorly suited to trees. Most areas of these soils are used for crops, but a few areas are in grass, and a few areas have potential as a source of sand and gravel. The limitations for many nonfarm uses are slight and severe.

Representative profile of Arvilla sandy loam, 1 to 6 percent slopes, in a cultivated field, 1,720 feet east and 120 feet north of the southwest corner of sec. 28, T. 144 N., R. 52 W.

Ap—0 to 7 inches, black (10YR 2/1) sandy loam, very dark gray (10YR 3/1) when dry; weak coarse granular structure; slightly hard, very friable, slightly sticky and slightly plastic; common roots and pores; neutral; abrupt smooth boundary.

A12—7 to 11 inches, black (10YR 2/1) sandy loam, very dark gray (10YR 3/1) when dry; weak medium subangular blocky structure parting to weak medium granular; slightly hard, very friable, slightly sticky and slightly plastic; common roots and pores; neutral; clear wavy boundary.

B2—11 to 17 inches, very dark grayish brown (10YR 3/2) sandy loam, brown (10YR 4/3) when dry; weak medium prismatic structure; slightly hard, very friable, slightly sticky and slightly plastic; few roots and common pores; neutral; clear wavy boundary.

IIC1—17 to 50 inches, grayish brown (10YR 5/2) sand and gravel, light gray (10YR 7/1) when dry; single grained; loose, nonsticky and nonplastic; lime coatings on bottom of pebbles; strongly effervescent; mildly alkaline; gradual wavy boundary.

IIC2—50 to 60 inches, olive brown (2.5Y 4/4) sand and gravel, light brownish gray (2.5Y 6/2) when dry; single grained; loose, nonsticky and nonplastic; slightly effervescent; mildly alkaline.

The thickness of the solum and the depth to sand and gravel ranges from 14 to 24 inches. The A horizon ranges from sandy loam to loam, but is dominantly sandy loam. It is black or very dark gray and ranges from 7 to 12 inches in thickness. The B horizon ranges from coarse sandy loam to loam, but is dominantly sandy loam. It is very dark gray to dark grayish brown and ranges from 6 to 10 inches in thickness. The IIC horizon has more than 10 percent, by volume, of gravel, and it commonly averages 20 to 35 percent gravel.

Arvilla soils are near the Hecla, Maddock, and Sioux soils. They have a C horizon of sand and gravel, but Hecla and Maddock soils do not. They have a thicker solum than Sioux soils.

AvB—Arvilla sandy loam, 1 to 6 percent slopes. This nearly level and gently sloping soil is on beaches on the delta and between the beaches. It has the profile described as representative of the series. In a few areas the surface layer is fine sandy loam or loam instead of sandy loam.

Included with this soil in mapping are some areas of Hecla sandy loam, which makes up not more than 12 percent of this mapping unit, and Sioux gravelly sandy loam, which makes up not more than 8 percent. Also included are areas of Arvilla sandy loam, which has a substratum of silt loam, clay loam, silty clay loam, or silty clay at a depth of 40 to 60 inches and which makes up not more than 15 percent of this mapping unit. The Hecla soil is on the lower, plane and slightly convex slopes of beaches, and the Sioux soil is on the convex, sloping crests of beaches. Other inclusions are some small areas where this soil is eroded and the subsoil is exposed. About 80 percent of this acreage has slopes of 1 to 3 percent. A few small wet areas and a few small areas that are steep and have short slopes are indicated by spot symbols on the soil map.

Runoff is slow. Soil blowing is a severe hazard. The available water capacity is low.

Most areas of this soil are used for crops, but a few areas are in grass that is cut for hay or used for pasture. A few areas have potential as a source of sand and gravel. This soil is fairly well suited to farming, but in most places it is poorly suited to trees. Controlling soil blowing, conserving moisture, and improving fertility are the main concerns of management. Capability unit IIIes–3; windbreak suitability group 6.

Bearden Series

The Bearden series consists of deep, somewhat poorly drained, nearly level soils. These soils are on low beaches, in broad areas between beaches, and in broad areas on the delta and glacial lake plain. They formed in medium textured and moderately fine textured glacial lacustrine deposits.

In a representative profile the surface layer is silty clay loam (fig. 6) about 14 inches thick. The upper part is black, and the lower part is dark gray and has an accumulation of lime. The underlying material, to a depth of 21 inches, is light brownish gray silty clay loam that has an accumulation of lime. Below this is light olive brown silty clay loam that is mottled with gray and yellowish brown in the lower part.

Permeability is moderately slow, except in areas where the substratum is clay. The available water capacity is high, except in saline areas. The organic-matter content is high, and fertility is medium. These soils have a seasonal high water table 3 to 5 feet below the surface.

In most areas Bearden soils are well suited to farming and to trees. Nearly all areas of these soils are used for crops, but a few areas are in grass. The limitations for nonfarm use range from slight to severe.

Representative profile of Bearden silty clay loam, in an area of Bearden-Overly silty clay loams, in a cultivated field, 1,409 feet east and 396 feet south of the northwest corner of sec. 36, T. 146 N., R. 52 W.

Ap—0 to 8 inches, black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) when dry; moderate fine subangular blocky structure parting to moderate fine granular; hard, friable, sticky and plastic; many roots and pores; slightly effervescent; mildly alkaline; abrupt smooth boundary.

A12ca—8 to 14 inches, dark gray (10YR 4/1) silty clay loam, gray (10YR 5/1) when dry; weak coarse prismatic structure parting to weak coarse blocky;

Figure 6.—**Profile of Bearden silty clay loam. The dark-colored surface layer is underlain by a light-colored layer that has an accumulation of lime.**

hard, friable, sticky and plastic; common roots and pores; violently effervescent; mildly alkaline; clear wavy boundary.

C1ca—14 to 21 inches, light brownish gray (2.5Y 6/2) silty clay loam, light gray (2.5Y 7/2) when dry; weak coarse prismatic structure; hard, friable, sticky and plastic; few roots and common pores; violently effervescent; mildly alkaline; clear wavy boundary.

C2—21 to 38 inches, light olive brown (2.5Y 5/4) silty clay loam, pale yellow (2.5Y 7/4) when dry; weak coarse prismatic structure; hard, friable, sticky and plastic; few roots and pores; strongly effervescent; mildly alkaline; gradual wavy boundary.

C3—38 to 60 inches, light olive brown (2.5Y 5/4) silty clay loam, pale yellow (2.5Y 7/4) when dry; many medium distinct gray (5Y 5/1) mottles and common medium prominent yellowish brown (10Y 5/6) mottles; massive; hard, friable, sticky and plastic; strongly effervescent; mildly alkaline.

The A horizon ranges from 6 to 14 inches in thickness and is silt loam or silty clay loam. The Cca horizon ranges from 6 to 20 inches in thickness and is silt loam or silty clay loam. It is strongly or violently effervescent. The C horizon is silt loam or silty clay loam, but below a depth of 40 inches, it is commonly silt loam or silty clay loam or, in places, fine sand or clay. Gypsum crystals and other salts are common in some areas. This horizon is mildly alkaline or moderately alkaline.

Bearden soils formed in material similar to that in which the Colvin, Overly, and Perella soils formed. They are better drained than Colvin soils. They have, within 16 inches of the surface, a layer where lime has accumulated, but this layer is lacking in Overly and Perella soils. They are more poorly drained than Overly soils and better drained than Perella soils.

Bd—Bearden silt loam, saline. This nearly level soil is in seepage areas below beaches and in broad areas on the delta and glacial lake plain. It has a profile similar to the one described as representative of the series, but it is moderately saline silt loam throughout the profile. The surface layer is silt loam in most places, but it is silty clay loam in a few places. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Perella silt loam, which makes up not more than 10 percent of this mapping unit, and Bearden silt loam, which makes up not more than 15 percent. The Perella soil is in shallow depressions, and the Bearden soil is not saline. Small wet areas are indicated by a spot symbol on the soil map.

The available water capacity is moderate. Surface runoff is slow. This soil contains enough soluble salts to affect plant growth. The hazard of soil blowing is moderate.

Most areas of this soil are used for crops. Some areas are in grass that is cut for hay or used for pasture. This soil is fairly well suited to farming, but it is not suited to trees. The main concerns of management are controlling salinity and soil blowing, selecting salt-tolerant crops, and improving fertility. Capability unit IIIs–4L; windbreak suitability group 10.

Be—Bearden silty clay loam. This nearly level soil is on narrow beaches, in the broad areas between the beaches, and in broad areas on the delta and glacial lake plain. It has a profile similar to the one described as representative of the series, but in most areas the surface layer is not so thick. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Overly silty clay loam, which makes up not more than 12 percent of this mapping unit, and Perella silty clay loam, which makes up not more than 8 percent. The Overly soil is on plane and slightly concave slopes, and the Perella soil is in shallow depressions and swales. Small wet areas, small saline areas, and small areas that are steep and have short slopes are indicated by spot symbols on the soil map.

Runoff is slow. The hazard of soil blowing is moderate.

Nearly all areas of this soil are used for crops. This soil is well suited to farming and to trees. Controlling soil blowing, improving fertility, and maintaining

tilth are the main concerns of management. Capability unit IIe–4L; windbreak suitability group 1.

Bg—Bearden silty clay loam, clay substratum. This nearly level soil is in broad areas on the delta and glacial lake plain. It has a profile similar to the one described as representative of the series, but a substratum of clay is 40 to 60 inches below the surface. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Fargo silty clay loam, which makes up not more than 10 percent of this mapping unit, and Enloe silty clay loam or Galchutt silty clay loam, or both, which make up not more than 15 percent. The Fargo soil is on plane and slightly concave side slopes, and the Enloe and Galchutt soils are in shallow depressions and swales. Also included are some areas of Bearden silty clay loam that lacks a substratum of clay and which makes up not more than 15 percent of this mapping unit, and a soil similar to Bearden silty clay loam that has a clay substratum 24 to 40 inches below the surface, which makes up not more than 15 percent. Small wet areas and small areas that are steep and have short slopes are indicated by spot symbols on the soil map.

Permeability is moderately slow above the clay substratum and slow in it. Runoff is slow. The hazard of soil blowing is moderate.

Nearly all areas of this soil are used for crops. This soil is well suited to farming and to trees. Controlling soil blowing, improving fertility, and maintaining tilth are the main concerns of management. Capability unit IIe–4L; windbreak suitability group 1.

Bn—Bearden-Lindaas silty clay loams. The soils of this complex are nearly level and are in broad areas between the beaches, on the delta, and on the glacial lake plain. The Bearden soil is on plane and slightly convex slopes, and the Lindaas soil is on slightly concave slopes. This complex is at least 65 percent Bearden silty clay loam and is 30 percent Lindaas silty clay loam. Slopes are 0 to 1 percent.

In a few areas these soils have a surface layer of silt loam instead of silty clay loam. The Bearden soil has a profile similar to the one described as representative of the series, but the surface layer is not so thick in some areas. This soil is calcareous at or near the surface. The Lindaas soil has the profile described as representative of the series. It has a noncalcareous surface layer (fig. 7).

Included with this complex in mapping are some areas of either Overly silty clay loam or Colvin silty clay loam, or both. The Overly soil is on plane and slightly convex slopes, and the Colvin soil is in depressions or on the rim of depressions. These included areas make up 5 percent or less of this mapping unit. Small saline areas and small areas that are steep and have short slopes are indicated by spot symbols on the soil map.

The hazard of soil blowing is moderate. Runoff is slow on the Bearden soil and very slow on the Lindaas soil.

Figure 7.—A plowed field of Bearden-Lindaas silty clay loams. The Bearden soil is lighter colored, and the Lindaas soil is darker colored.

Nearly all areas of this complex are used for crops. This complex is well suited to farming and, in most areas, to trees. Controlling soil blowing, removing excess water, and improving and maintaining tilth and fertility are the main concerns of management. In most areas surface drainage is needed on the Lindaas soil because, unless drained, the Lindaas soil is occasionally ponded in spring when rainfall is high and when snow melts rapidly. Capability unit IIew–4L; Bearden part in windbreak suitability group 1, Lindaas part in windbreak suitability group 2.

Bo—Bearden-Overly silty clay loams. The soils of this complex are nearly level and are in broad areas on the delta and on the glacial lake plain. The Bearden soil is on plane and slightly convex slopes, and the Overly soil is on plane and slightly concave slopes. This complex is at least 60 percent Bearden silty clay loam and is about 35 percent Overly silty clay loam. These soils form such an intricate pattern that it is not practical to map them separately at the scale used for the soil map. Slopes are 0 to 1 percent.

The Bearden soil has the profile described as representative of the series. It is calcareous at or near the surface. The Overly soil has a noncalcareous surface layer.

Included with this complex in mapping are some areas of Perella silty clay loam, which makes up not more than 5 percent of this mapping unit. The Perella soil is in depressions and swales. Also included are a few small areas of a somewhat poorly drained Overly soil. Small wet areas, small saline areas, and small areas that are steep and have short slopes are indicated by spot symbols on the soil map.

The hazard of soil blowing is moderate. Runoff is slow.

Nearly all areas of this complex are used for crops. This complex is well suited to farming and to trees. Controlling soil blowing and improving and maintaining fertility and tilth are the main concerns of management. Capability unit IIe–4L; windbreak suitability group 1.

Bp—Bearden-Perella silty clay loams. The soils of this complex are nearly level and are in broad areas between the beaches, on the delta, and on the glacial lake plain. The Bearden soil is on plane and slightly convex slopes, and the Perella soil is on slightly concave slopes. This complex is about 60 percent Bearden silty clay loam and about 25 percent Perella silty clay loam. Slopes are 0 to 1 percent.

In a few areas these soils have a surface layer of silt loam instead of silty clay loam. The Bearden soil has a profile similar to the one described as representative of the series, but in some areas the surface layer is not so thick. This soil is calcareous at or near the surface. The Perella soil has the profile described as representative of the series. It has a noncalcareous surface layer.

Included with this complex in mapping are some areas of Glyndon silt loam, which makes up not more than 10 percent of this mapping unit, and Colvin silty clay loam, which makes up not more than 5 percent. The Glyndon soil is on plane and slightly convex slopes, and the Colvin soil is in depressions and swales and on the rims of depressions. A few small saline areas are indicated by a spot symbol on the soil map.

The hazard of soil blowing is moderate. Runoff is slow on the Bearden soil and very slow on the Perella soil.

Nearly all areas of this complex are used for crops. This complex is well suited to farming and to trees. Controlling soil blowing, removing excess water, and improving and maintaining tilth and fertility are the main concerns of management. In most areas surface drainage is needed on the Perella soil because this Perella soil is occasionally ponded in spring when rainfall is high and when snow melts rapidly. Capability unit IIew–4L; Bearden part in windbreak suitability group 1, Perella part in windbreak suitability group 2.

Bs—Bearden and Glyndon silt loams. The soils in this undifferentiated group are nearly level and are in broad areas between beaches, on the delta, and on the glacial lake plain. Some areas consist of Bearden silt loam, some of Glyndon silt loam, and others of both soils. Slopes are 0 to 1 percent.

The Bearden soil has a profile similar to the one described as representative of the series, but it is silt loam throughout its profile in most areas.

Included with this group in mapping are some areas of Overly silty clay loam, which makes up not more than 15 percent of this mapping unit, and Perella silt loam, which makes up not more than 10 percent. The Overly soil is on plane and slightly concave slopes, and the Perella soil is in depressions and swales. Small wet areas and small saline areas are also included. These are indicated on the soil map by the symbols for wet areas and saline areas.

The hazard of soil blowing is moderate on both soils. Runoff is slow.

Nearly all the acreage is used for crops (fig. 8). These soils are well suited to farming and to trees. Controlling soil blowing and improving fertility are the main concerns of management. Capability unit IIe–4L; windbreak suitability group 1.

Beotia Series

The Beotia series consists of deep, well drained, nearly level soils. These soils are on low beaches, in broad areas between beaches, and in areas adjacent to the breaks to the bottom lands along streams of the delta and glacial lake plain. They formed in medium textured glacial lacustrine deposits.

In a representative profile the surface layer is black silt loam about 12 inches thick. The subsoil is very dark grayish brown silt loam about 11 inches thick. The upper part of the underlying material is light brownish gray silt loam 6 inches thick. The lower part is light olive brown silt loam that is mottled in the lower part with gray and dark yellowish brown.

Permeability is moderate, and the available water capacity is high. The organic-matter content and fertility are high. These soils have a deep water table.

Beotia soils are well suited to farming and to trees. All of these soils are used for crops. The limitations for many nonfarm uses are slight or moderate.

Representative profile of Beotia silt loam, in a cultivated field, 1,660 feet east and 125 feet north of the southwest corner of sec. 10, T. 148 N., R. 53 W.

Ap—0 to 7 inches, black (10YR 2/1) silt loam, dark gray

Figure 8.—**Potatoes on Bearden and Glyndon silt loams. The soils are protected from blowing by field windbreaks.**

(10YR 4/1) when dry; moderate medium granular structure; slightly hard, friable, sticky and plastic; many roots and pores; neutral; abrupt smooth boundary.

A12—7 to 12 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) when dry; weak coarse blocky structure parting to moderate medium granular; slightly hard, friable, sticky and plastic; common roots and many pores; neutral; clear wavy boundary.

B2—12 to 23 inches, very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) when dry; moderate coarse and medium prismatic structure parting to weak medium blocky; slightly hard, friable, sticky and plastic; few roots and common pores; mildly alkaline; clear wavy boundary.

C1ca—23 to 29 inches, light brownish gray (2.5Y 6/2) silt loam, white (2.5Y 8/2) when dry; weak coarse and medium prismatic structure; slightly hard, friable, sticky and plastic; few roots and common pores; violently effervescent; mildly alkaline; gradual wavy boundary.

C2—29 to 44 inches, light olive brown (2.5Y 5/4) silt loam, pale yellow (2.5Y 8/4) when dry; weak medium and coarse prismatic structure; hard, friable, sticky and plastic; strongly effervescent; mildly alkaline; gradual wavy boundary.

C3—44 to 60 inches, light olive brown (2.5Y 5/4) silt loam, pale yellow (2.5Y 7/4) when dry; many coarse distinct gray (2.5Y 6/0) mottles and few fine distinct dark yellowish brown mottles; massive; hard, friable, sticky and plastic, slightly effervescent; mildly alkaline.

The solum ranges from 16 to 32 inches in thickness. The A horizon is black or very dark gray and ranges from 6 to 12 inches in thickness. The B horizon is very dark brown to dark grayish brown and ranges from 10 to 20 inches in thickness. It is commonly silt loam, but it is silty clay loam in a few places. In some places the lower part of the B horizon is calcareous. The C horizon is commonly silt loam above a depth of 40 inches, but it is silty clay loam in a few places. Below a depth of 40 inches, it is mainly silt loam, but it is loam, clay loam, silty clay, or clay in a few places.

Beotia soils are near the Bearden, Great Bend, and Perella soils. They are better drained than Bearden soils and, unlike those soils, lack a layer that has an accumu-

lation of lime within 16 inches of the surface. They are darker colored to a greater depth than Great Bend soils. They are better drained than Perella soils and, unlike those soils, lack mottles so near the surface.

Bt—Beotia silt loam. This nearly level soil is on low beaches, in broad areas between beaches, and in areas adjacent to the breaks to bottom lands along streams on the delta and glacial lake plain. It has the profile described as representative of the series. The surface layer is silt loam in most areas, but it is silty clay loam in a few areas. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Bearden silt loam, which makes up not more than 10 percent of this mapping unit, Great Bend silt loam which makes up not more than 5 percent, and Perella silt loam which makes up not more than 5 percent. The Bearden soil is on plane and slightly convex slopes, the Great Bend soil is on convex slopes, and the Perella soil is in depressions and swales. Also included are small wet areas, a few small saline areas, and a few small areas that are steep and have short slopes. These are indicated on the soil map by the appropriate symbol.

Soil blowing is a slight hazard. Runoff is slow.

All areas of this soil are used for crops. This soil is well suited to farming and to trees. Conserving moisture and maintaining organic-matter content are the main concerns of management. Capability unit IIc–6; windbreak suitability group 1.

Bohnsack Series

The Bohnsack series consists of deep, nearly level, somewhat poorly drained soils. These soils are in broad areas between the beaches. They formed in medium textured water-worked glacial till and the underlying medium textured glacial melt–water deposits.

In a representative profile the surface layer is black loam about 8 inches thick. The underlying material, to a depth of 24 inches, is grayish brown loam that has an accumulation of lime. The lower part is olive brown and light olive brown silt loam mottled with brown and gray.

Permeability is moderate, and the available water capacity is high. The organic-matter content is high, and fertility is medium. These soils have a seasonal high water table 3 to 5 feet below the surface.

Bohnsack soils are well suited to farming and to trees. Nearly all of the acreage is used for crops, but few areas are in grass. The limitations for many nonfarm uses are moderate and severe.

Representative profile of Bohnsack loam, in a cultivated field, 75 feet north and 2,260 feet east of the southwest corner of sec. 34, T. 145 N., R. 52 W.

Ap—0 to 8 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) when dry; weak medium subangular blocky structure parting to weak medium granular; slightly hard, friable, slightly sticky and slightly plastic; many roots and pores; about 5 percent pebbles; slightly effervescent; mildly alkaline; abrupt smooth boundary.

C1ca—8 to 14 inches, grayish brown (10YR 5/2) loam, light gray (10YR 7/2) when dry; weak coarse prismatic structure parting to weak medium granular; slightly hard, friable, slightly sticky and slightly plastic; common roots and many pores; tongues from the A horizon extend into this horizon; about 5 percent pebbles; violently effervescent; mildly alkaline; gradual wavy boundary.

C2ca—14 to 24 inches, grayish brown (2.5Y 5/2) loam, light gray (2.5Y 7/2) when dry; weak coarse prismatic structure parting to weak medium granular; slightly hard, friable, slightly sticky and slightly plastic; common roots and pores; common medium nests of gypsum crystals; about 5 percent pebbles; violently effervescent; mildly alkaline; gradual wavy boundary.

IIC3—24 to 37 inches, olive brown (2.5Y 4/4) silt loam, light yellowish brown (2.5Y 6/4) when dry; weak coarse prismatic structure; slightly hard, friable, slightly sticky and slightly plastic; few roots and common pores; strongly effervescent; mildly alkaline; gradual wavy boundary.

IIC4—37 to 60 inches, light olive brown (2.5Y 5/4) silt loam, pale yellow (2.5Y 7/4) when dry; few fine distinct brown mottles and common medium distinct gray (5Y 5/1) mottles; laminae parting to weak fine blocky structure; soft, friable, slightly sticky and slightly plastic; slightly effervescent; mildly alkaline.

The depth to the silt loam glacial melt-water deposit ranges from 20 to 40 inches. The upper part of the soil profile is dominantly loam, but it is silt loam in places and contains 2 to 10 percent rock fragments. The A horizon is black or very dark gray and ranges from 7 to 15 inches in thickness. Lime has accumulated in some places in the lower part of the A horizon. The C horizon is mildly alkaline or moderately alkaline. The Cca horizon is dark gray to grayish brown, and it is 6 to 20 inches thick. The IIC horizon is commonly silt loam, but it is silt or very fine sandy loam in some places. In some profiles a thin layer of gravelly or stony material is at the contact of the water-worked glacial till with the underlying glacial melt-water deposit. The lower part of IIC horizon has few to many, faint to prominent mottles.

Bohnsack soils are near the Doran, Glyndon, and Tiffany soils. Unlike Doran soils, they have, within 16 inches of the surface, a layer in which lime has accumulated. Bohnsack soils contain more sand and less silt in the upper part of the soil than Glyndon soils. They are better drained than Tiffany soils and, unlike those soils, have a layer in which lime has accumulated within 16 inches of the surface.

Bu—Bohnsack loam. This nearly level soil is in broad areas between the beaches. It has the profile described as representative of the series. The surface layer is loam in most places, but it is silt loam in a few areas. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Emrick loam, which makes up not more than 10 percent of this mapping unit, Perella silt loam, which makes up 5 percent, and Tiffany loam, which makes up 8 percent. The Emrick soil is on plane and slightly concave slopes, and the Perella and Tiffany soils are in shallow depressions. A few small saline areas were also included and are indicated on the soil map by the symbol for a saline area.

Soil blowing is a moderate hazard. Runoff is slow. In most areas common small stones and a few large stones interfere with tillage.

Nearly all areas of this soil are used for crops, but a few areas are in grass that is cut for hay or used for pasture. This soil is well suited to farming and to trees. Controlling soil blowing, removing stones, and improving fertility are the main concerns of management. Capability unit IIe–4L; windbreak suitability group 1.

Bv—Bohnsack-Tiffany loams. The soils of this complex are nearly level and are in broad areas between the beaches. The Bohnsack soil is on plane and slightly convex slopes, and the Tiffany soil is in shallow depres-

sions and swales. This complex is at least 58 percent Bohnsack loam and 28 percent Tiffany loam. Slopes are 0 to 1 percent.

The Tiffany soil has the profile described as representative of the series.

Included with this complex in mapping are some areas of Emrick loam, which makes up not more than 6 percent of this mapping unit, and Perella silt loam, which makes up not more than 8 percent. The Emrick soil is on plane and slightly concave slopes, and the Perella soil is in depressions.

The hazard of soil blowing is moderate. Runoff is slow on the Bohnsack soil and very slow on the Tiffany soil. In most areas of the Tiffany soils, water ponds for short periods in spring during periods when rainfall is heavy and snow melts rapidly. A few small to large stones interfere with tillage.

Nearly all areas of this complex are used for crops, but a few areas are in grass that is cut for hay or used for pasture. This complex is well suited to farming and to trees. Controlling soil blowing and removing excess water are the main concerns of management. Capability unit IIew–4L; Bohnsack part in windbreak suitability group 1, Tiffany part in windbreak suitability group 2.

Borup Series

The Borup series consists of deep, nearly level, poorly drained soils. These soils are in shallow depressions, swales, and seepage areas on the delta and between the beaches. They formed in medium textured glacial melt-water deposits.

In a representative profile the surface layer is black silt loam about 10 inches thick. The underlying material, to a depth of 28 inches, is silt loam that has an accumulation of lime. The upper part is gray, and the lower part is olive gray and mottled with dark yellowish brown. Below this is very fine sandy loam mottled with gray and reddish brown. The upper part of this layer is olive gray, and lower part is light olive brown.

Permeability is moderate in the surface layer and moderately rapid in the underlying material. The available water capacity is high, except in saline areas. The organic-matter content is high, and fertility is medium. These soils have a seasonal water table 1 to 3 feet below the surface.

In most areas Borup soils are well suited to farming and, if excess water is removed, to trees. Most areas of these soils are used for crops, but some areas are in grass. The limitations for most nonfarm uses are severe.

Representative profile of Borup silt loam, in a cultivated field, 1,971 feet east and 240 feet north of the southwest corner of sec. 3, T. 147 N., R. 53 W.

Ap—0 to 7 inches, black (10Y 2/1) silt loam, very dark gray (10YR 3/1) when dry; weak medium granular structure; soft, friable, slightly sticky and slightly plastic; few roots and pores; strongly effervescent; mildly alkaline; abrupt smooth boundary.

A12—7 to 10 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) when dry; weak coarse blocky structure parting to weak medium granular; soft, friable, slightly sticky and slightly plastic; few roots and pores; strongly effervescent; mildly alkaline; clear smooth boundary.

C1cag—10 to 21 inches, gray (5Y 5/1) silt loam, light gray (5Y 7/1) when dry; weak coarse prismatic structure; slightly hard, friable, sticky and plastic; few roots and common pores; violently effervescent; mildly alkaline; gradual smooth boundary.

C2cag—21 to 28 inches, olive gray (5Y 5/2) silt loam, white (5Y 8/2) when dry; few fine distinct dark yellowish brown mottles; weak coarse prismatic structure; slightly hard, friable, slightly sticky and slightly plastic; few roots and common pores; violently effervescent; mildly alkaline; gradual wavy boundary.

C3g—28 to 33 inches, olive gray (5Y 5/2) very fine sandy loam, light gray (5Y 7/2) when dry; many medium distinct gray (5Y 5/1) mottles and few fine distinct reddish brown mottles; weak coarse prismatic structure; soft, very friable, nonsticky and nonplastic; few roots and common pores; strongly effervescent; moderately alkaline; gradual wavy boundary.

C4—33 to 60 inches, light olive brown (2.5Y 5/4) very fine sandy loam, pale yellow (2.5Y 7/4) when dry; common medium distinct gray (5Y 5/1) mottles and many coarse prominent reddish brown (5Y 4/4) mottles; massive; soft, very friable, nonsticky and nonplastic; slightly effervescent; mildly alkaline.

The A horizon ranges from 7 to 15 inches in thickness and is black or very dark gray. It is silt loam in most areas, but it is loam or very fine sandy loam in some areas. The lower part of the A horizon has an accumulation of lime in places. The C horizon is very fine sandy loam in most places, but it is very fine sand or silt loam in some places. Gypsum crystals and other salts are common in some areas. This horizon is mildly alkaline or moderately alkaline. The Ccag horizon, ranging from 8 to 20 inches in thickness, is dark gray to light gray silt loam, loam, or very fine sandy loam.

Borup soils formed in material similar to that in which the Eckman, Gardena, and Glyndon soils formed. They are calcareous at the surface and, unlike Eckman soils, lack a B horizon. Borup soils have, within 16 inches of the surface, a layer where lime has accumulated, but this layer is lacking in Gardena soils. They are more poorly drained than Glyndon soils.

Bw—Borup silt loam. This soil is in shallow depressions, swales, and seepage areas on the delta and between the beaches. It has the profile described as representative of the series. The surface layer is silt loam in most areas, but it is loam or very fine sandy loam in a few areas. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Perella silt loam, which makes up not more than 10 percent of this mapping unit, Borup silt loam, saline, which makes up not more than 15 percent, and Borup soils which have a substratum of sand, clay loam, or silty clay at a depth of 40 to 60 inches and which make up not more than 10 percent. The Perella soil is on circular or elongated, concave slopes. Small saline areas and a few small wet areas are indicated by a spot symbol on the soil map.

A seasonal water table is near the surface in spring and during periods of heavy rainfall. Runoff is very slow. Water ponds in some places for short periods in spring when rainfall is heavy and snow melts rapidly. Soil blowing is a moderate hazard.

Most areas of this soil are used for crops, but some areas are in grass that is cut for hay or used for pasture. If excess water is removed, this soil is well suited to farming and, in most places, to trees. Removing ex-

cess water and improving fertility are the main concerns of management. Capability unit IIw–4L; windbreak suitability group 2.

Bx—Borup silt loam, saline. This soil is in shallow depressions, swales, and seepage areas on the delta and between the beaches. It has a profile similar to the one described as representative of the series, but it is saline and has a thicker surface layer. The surface layer is silt loam in most places, but it is loam in a few places. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Perella silt loam, which makes up not more than 10 percent of this mapping unit, and Borup silt loam, which is not saline and which makes up not more than 15 percent. The Perella soil is on circular or elongated, concave slopes.

The available water capacity is moderate. This soil contains enough soluble salts to affect plant growth. A seasonal water table is near the surface in spring and during periods of heavy rainfall. Runoff is very slow, and water ponds in some places for short periods in spring when rainfall is heavy and snow melts rapidly. Soil blowing is a moderate hazard.

Most areas of this soil are used for crops, but some areas are in grass that is cut for hay or used for pasture. This soil is fairly well suited to farming, but it is not suited to trees. Controlling salinity, selecting salt-tolerant crops, and removing excess water are the main concerns of management. Capability unit IIIs–4L; windbreak suitability group 10.

Cashel Series

The Cashel series consists of deep, nearly level to sloping, somewhat poorly drained soils. These soils are on flood plains, stream banks, and abandoned channels on bottom lands along streams. They formed in fine textured recent alluvial deposits.

In a representative profile the surface layer is very dark grayish brown silty clay about 9 inches thick. The underlying material, to a depth of 30 inches, is finely stratified grayish brown silty clay. Below this is a thin buried layer of very dark gray silty clay. The lower part of the underlying material is very dark grayish brown silty clay.

Permeability is moderately slow, and the available water capacity is high. The organic-matter content is moderate, and fertility is high. These soils have a low water table and are subject to flooding by streams.

In most areas Cashel soils are well suited to farming and to trees. Most areas of these soils are used for crops. Some areas are in native woodland, and a few of these areas are used for pasture. The limitations for most nonfarm uses are severe.

Representative profile of Cashel silty clay, 1 to 3 percent slopes, in a cultivated field, 2,504 feet north and 750 feet east of the southwest corner of sec. 25, T. 146 N., R. 49 W.

Ap—0 to 7 inches, very dark grayish brown (10YR 3/2) silty clay, grayish brown (10YR 5/2) when dry; moderate fine granular structure; hard, friable, sticky and plastic; many roots and common pores; slightly effervescent; mildly alkaline; abrupt smooth boundary.

A12—7 to 9 inches, very dark grayish brown (10YR 3/2) finely stratified silty clay, grayish brown (10YR 5/2) when dry; weak medium blocky structure parting to moderate fine granular; hard, friable, sticky and plastic; many roots and common pores; slightly effervescent; mildly alkaline; clear smooth boundary.

C1—9 to 30 inches, grayish brown (10YR 5/2) finely stratified silty clay, light brownish gray (10YR 6/2) when dry; weak medium blocky structure; hard, friable, sticky and plastic; common roots and pores; slightly effervescent; mildly alkaline; clear smooth boundary.

A1b—30 to 31 inches, very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) when dry; weak medium blocky structure; hard, friable, sticky and plastic; few roots and common pores; slightly effervescent; mildly alkaline; abrupt smooth boundary.

C2—31 to 60 inches, very dark grayish brown (2.5Y 3/2) silty clay, grayish brown (2.5Y 5/2) when dry; weak medium blocky structure; hard, friable, sticky and plastic; few roots and common pores in upper part; slightly effervescent; mildly alkaline.

This soil is silty clay or clay and is slightly effervescent and strongly effervescent. The soil contains one or more dark colored buried A horizons that are 1 to 5 inches thick. The A horizon ranges from very dark brown to dark gray. In some places dark colored layers that are ⅛ to ¾ inch thick occur at random in the soil. In some areas, the C horizon has a few tiny fragments of broken snail shells.

Cashel soils are near the Fargo, Ludden, and Wahpeton soils. They are better drained than Fargo soils, but unlike those soils, they have a buried A horizon. Cashel soils are better drained and have a lighter colored A horizon than Ludden soils. They have a lighter colored A horizon than Wahpeton soils.

CaA—Cashel silty clay, 1 to 3 percent slopes. This nearly level soil is on the flood plains of the Red River of the North and its tributaries. It has the profile described as representative of the series.

Included with this soil in mapping are some areas of Wahpeton silty clay, which makes up not more than 15 percent of this mapping unit, and Ludden silty clay, which makes up not more than 5 percent. The Wahpeton soil is in the higher areas, and the Ludden soil is in abandoned stream channels. Also included are small areas where slopes are 3 to 6 percent. A few small areas that are steep and have short slopes are indicated by a spot symbol on the soil map.

This soil is subject to flooding by streams in spring when rainfall is heavy and snow melts rapidly. Runoff is slow.

Most areas of this soil are used for crops, but some areas are in native woodland. A few areas of native woodland are used for pasture. This soil is well suited to farming and to trees. Maintaining tilth and the organic-matter content are the main concerns of management. Capability unit IIs–4; windbreak suitability group 1.

CaC—Cashel silty clay, channeled. This nearly level to sloping soil is on short, concave and convex side slopes of streambanks and abandoned channels on bottom lands along the Red River. Slopes are 1 to 9 percent.

Included with this soil in mapping are some areas of Nutley silty clay, which makes up not more than 15 percent of this mapping unit, Wahpeton silty clay, which makes up not more than 10 percent, and Ludden silty clay, which makes up not more than 5 percent.

The Nutley soil is on breaks to bottom lands, the Wahpeton soil is in the higher areas, and the Ludden soil is in abandoned stream channels. Also included are a few small areas where slopes are more than 9 percent.

This soil is subject to flooding by streams in spring when rainfall is heavy and snow melts rapidly. Runoff is slow.

Nearly all areas of this soil are in native woodland and grass, and some of these areas are used for pasture. A few small areas are used for crops, but generally areas of this soil are too irregularly shaped and too irregular in slope to be used for crops. This soil is well suited to trees. Controlling the erosion of streambanks and maintaining a high-quality plant cover are the main concerns of management. Capability unit VIw–4; windbreak suitability group 1.

Colvin Series

The Colvin series consists of deep, nearly level, poorly drained soils. These soils are in shallow depressions, swales, and seepage areas on the delta and glacial lake plain. They formed in medium textured and moderately fine textured glacial lacustrine deposits.

In a representative profile the surface layer is black silt loam about 8 inches thick. The underlying material, to a depth of 26 inches, is silt loam that has an accumulation of lime. The upper part is dark gray, and the lower part is gray and mottled with yellowish brown. Below this is silt loam that is light olive gray and mottled with yellowish brown and gray and mottled with dark brown.

Permeability is moderate and moderately slow. The available water capacity is high, except in saline areas. The organic-matter content is high, and fertility is medium. These soils have a seasonal water table 1 to 3 feet below the surface.

In most areas Colvin soils are well suited to farming and to trees if excess water is removed. Most areas of these soils are used for crops, but some areas are in grass. The limitations for many nonfarm uses are severe.

Representative profile of Colvin silt loam, in a cultivated field, 750 feet south and 63 feet west of the northeast corner of sec. 11, T. 146 N., R. 51 W.

Ap—0 to 8 inches, black (10YR 2/1) silt loam, very dark gray (10YR 3/1) when dry; weak fine granular structure; hard, friable, sticky and plastic; many roots and common pores; slightly effervescent; mildly alkaline; abrupt smooth boundary.

C1cag—8 to 18 inches, dark gray (5Y 4/1) silt loam, gray (5Y 6/1) when dry; weak coarse prismatic structure; hard, friable, sticky and plastic, few roots and common pores; violently effervescent; mildly alkaline; gradual wavy boundary.

C2cag—18 to 26 inches, gray (5Y 6/1) silt loam, light gray (5Y 7/1) when dry; few fine faint light olive brown mottles; weak coarse prismatic structure; hard, friable, sticky and plastic; few roots and common pores; violently effervescent; mildly alkaline; gradual wavy boundary.

C3g—26 to 42 inches, light olive gray (5Y 6/2) silt loam, light gray (5Y 7/2) when dry; common medium distinct yellowish brown (10YR 5/6) mottles; weak coarse prismatic structure; slightly hard, friable, slightly sticky and plastic; common pores; strongly effervescent; mildly alkaline; gradual wavy boundary.

C4g—42 to 60 inches, gray (5Y 5/1) silt loam, light gray (5Y 7/1) when dry; many coarse prominent dark brown (7.5YR 4/4) mottles; massive; slightly hard, friable, slightly sticky and plastic; slightly effervescent; mildly alkaline.

The soil material is commonly silt loam or silty clay loam throughout, but in places it is sand, clay loam, or clay below a depth of 40 inches. It ranges from mildly alkaline to strongly alkaline. Gypsum crystals and soluble salts are common in some places. The A horizon is 7 to 15 inches thick and is black or very dark gray. In some places, lime has accumulated in the lower part. Tongues of material from the A horizon extend to a depth of 20 inches in some places. The Ccag horizon ranges from 12 to 24 inches in thickness and is dark gray to light olive gray.

Colvin soils formed in material similar to that in which the Bearden, Ojata, and Perella soils formed. They are more poorly drained than Bearden soils. They contain less soluble salts than Ojata soils. Unlike Perella soils, Colvin soils have, within 16 inches of the surface, a layer in which lime has accumulated.

Co—Colvin silt loam. This soil is in shallow depressions, swales, and seepage areas on the delta and glacial lake plain. It has the profile described as representative of the series. The surface layer is silt loam in most places, but it is silty clay loam in a few places. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Perella silt loam, which makes up not more than 12 percent of this mapping unit, and Colvin silt loam, saline, which makes up not more than 15 percent. The Perella soil occurs as circular and elongated areas in the deeper parts of the depressions and swales. A few small saline areas and a few small very wet areas are indicated by spot symbols on the soil map.

Runoff is very slow. Water ponds in spring during periods when rainfall is heavy and snow melts rapidly. Soil blowing is a moderate hazard.

Most areas of this soil are used for crops, but some areas are in grass that is cut for hay or used for pasture. If excess water is removed, this soil is well suited to farming and, in most places, to trees. Removing excess water and improving fertility are the main concerns of management. Capability unit IIw–4L; windbreak suitability group 2.

Cs—Colvin silt loam, saline. This soil is in shallow depressions and seepage areas on the delta and glacial lake plain. It has a profile similar to the one described as representative of the series, but it is saline. The surface layer is silt loam in most places, but it is silty clay loam in some places. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Perella silt loam, which makes up not more than 15 percent of this mapping unit, and Colvin silt loam, which is not saline and which makes up not more than 15 percent. The Perella soil occurs as circular and elongated areas in the deeper parts of the depressions. A few small very wet areas are indicated by a spot symbol on the soil map.

The available water capacity is moderate. This soil contains enough soluble salts to affect plant growth. Runoff is very slow. Water ponds in some places for short periods in spring during periods when rainfall is heavy and snow melts rapidly. Soil blowing is a moderate hazard.

Most areas of this soil are used for crops, but some areas are in grass. This soil is fairly well suited to farming if salt-tolerant crops are grown. It is not suited to trees. Controlling salinity, selecting salt-

tolerant crops, and removing excess water are the main concerns of management. Capability unit IIIs–4L; windbreak suitability group 10.

Cut and Fill Land

Cut and fill land (Cu) consists of shallow excavations from which soil material has been removed. Nearly all of these excavations are along Interstate Highway 29, where soil material has been removed for fill for construction purposes. A few areas consist of shallow gravel pits that have been smoothed and covered with topsoil.

Most areas of this land type have a seasonal water table 1 to 5 feet below the surface in spring. Some areas where adequate outlets are not available are ponded in spring and during periods of heavy rainfall.

In most areas this land type is well suited to farming and to trees if excess water is removed. Most areas are used for crops, but a few areas are in grass. The main concerns of management are removing excess water and improving fertility. Capability unit IIw–4L; windbreak suitability group 2.

Divide Series

The Divide series consists of somewhat poorly drained, nearly level soils that are moderately deep to coarse sand and gravel. These soils are on low beaches on the delta and between the beaches. They formed in medium textured glacial melt-water deposits underlain by coarse sand and gravel.

In a representative profile the surface layer is black loam about 7 inches thick (fig. 9). The underlying material, to a depth of 25 inches, is loam that has an accumulation of lime. The upper part is gray, and the lower part is grayish brown. Below this is dark grayish brown and grayish brown coarse sand and gravel.

Permeability is moderate in the upper part and very rapid in the underlying coarse sand and gravel. The available water capacity is low. The organic-matter content is high, and fertility is medium. These soils have a seasonal water table 3 to 5 feet below the surface.

Divide soils are fairly well suited to farming and well suited to trees. Nearly all areas of these soils are used for crops, but a few small areas have potential as a source of sand and gravel. The limitations for many nonfarm uses are moderate and severe.

Representative profile of Divide loam, in a cultivated field, 1,131 feet west and 150 feet north of the southeast corner of sec. 14, T. 148 N., R. 52 W.

Ap—0 to 7 inches, black (10YR 2/1) loam, very dark gray (10YR 3/1) when dry; weak medium granular structure; slightly hard, friable, sticky and plastic; common roots and pores; strongly effervescent; mildly alkaline; abrupt smooth boundary.

C1ca—7 to 15 inches, gray (10YR 5/1) loam, light gray (10YR 7/1) when dry; weak coarse prismatic structure parting to weak medium granular; slightly hard, friable, sticky and plastic; common roots and many pores; violently effervescent; mildly alkaline; clear smooth boundary.

C2ca—15 to 25 inches, grayish brown (2.5Y 5/2) loam, light gray (2.5Y 6/1) when dry; weak coarse prismatic structure parting to weak medium granular; slightly hard, friable, sticky and plastic; few roots and common pores; violently effervescent; mildly alkaline; clear smooth boundary.

IIC3—25 to 36 inches, dark grayish brown (2.5Y 4/2) coarse sand and gravel, light brownish gray (2.5Y 6/2) when dry; single grained; loose, nonsticky and nonplastic; few roots and many pores; slightly effervescent; mildly alkaline; abrupt smooth boundary.

IIC4—36 to 60 inches, grayish brown (2.5Y 5/2) coarse sand and gravel, light gray (2.5Y 7/2) when dry; single grained; loose, nonsticky and nonplastic; slightly effervescent; mildly alkaline.

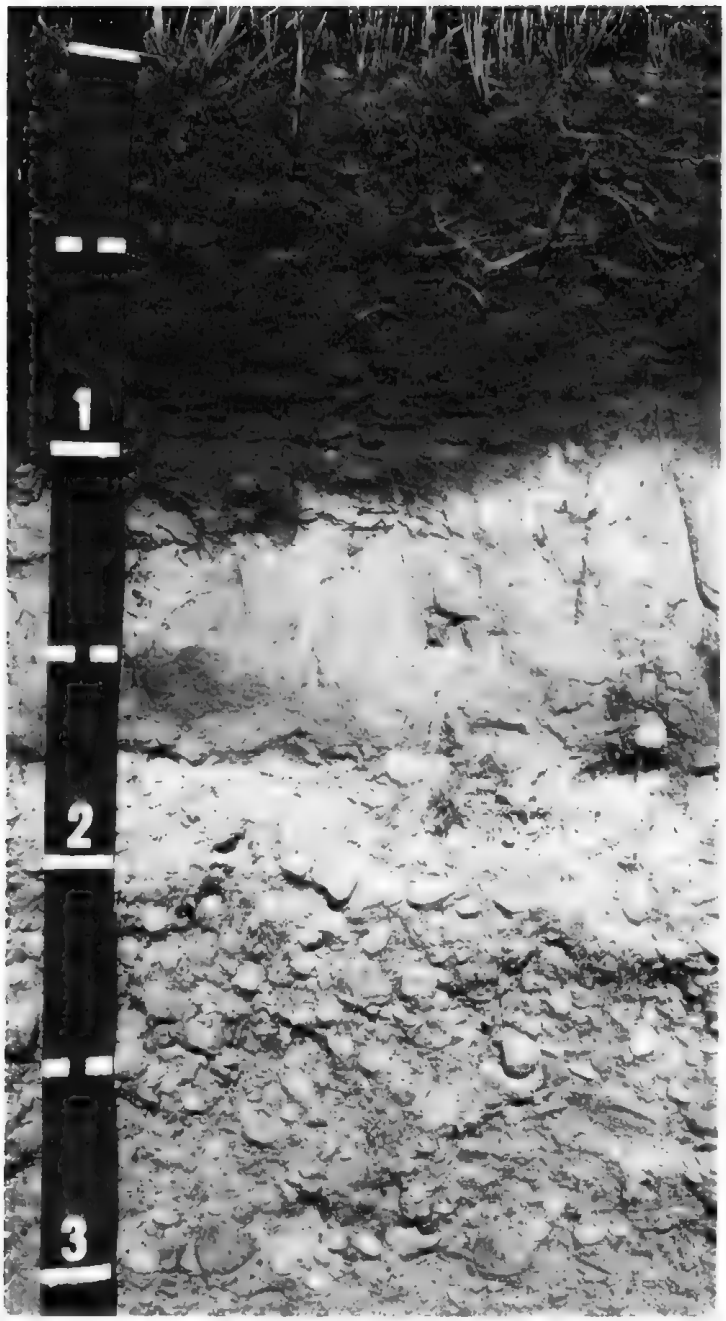

Figure 9.—**Profile of Divide loam. The dark-colored surface layer is underlain by a light-colored layer that has an accumulation of lime. Coarse sand and gravel are at a depth of 20 to 36 inches.**

Depth to coarse sand and gravel ranges from 20 to 36 inches. The soil is mildly alkaline or moderately alkaline. The A horizon ranges from 7 to 16 inches in thickness. It is black or very dark gray loam or silt loam. The Cca horizon ranges from 9 to 22 inches in thickness. It is dark gray to grayish brown loam or clay loam. Material from the Cca horizon extends into the upper part of the IIC horizon in some places. The IIC horizon has varying amounts of sand, as well as pebbles of quartzite and shale.

Divide soils are near the Gilby, Sioux, and Vallers soils. They have a thick underlying layer of coarse sand and gravel, which Gilby and Vallers soils lack. They are more poorly drained than Sioux soils and, unlike those soils, have a layer where lime has accumulated within 16 inches of the surface.

Dd—Divide loam. This nearly level soil is on low beaches on the delta and between the beaches. It has the profile described as representative of the series. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Glyndon or Hamerly soils, or both, which make up not more than 15 percent of this mapping unit, and a Divide soil, which contains less clay and fine sand or is coarser in the upper part of the soil than this Divide soil and which makes up not more than 15 percent. The Glyndon or Hamerly soils are on plane and slightly convex side slopes. Also included in mapping are a few small areas where slopes are 1 to 3 percent. A few small wet areas are indicated by a spot symbol on the soil map.

The available water capacity is low. Soil blowing is a moderate hazard. Runoff is slow.

Nearly all areas of this soil are used for crops. This soil is fairly well suited to farming and well suited to trees. A few areas have potential as a source of sand and gravel. Conserving moisture, controlling soil blowing, and improving fertility are the main concerns of management. Capability unit IIIs–6; windbreak suitability group 1.

Doran Series

The Doran series consists of deep, nearly level, somewhat poorly drained soils. These soils are on plane and slightly concave slopes between the beaches. They formed in a thin layer of moderately fine textured to fine textured glacial lacustrine deposits and water-worked glacial till underlain by medium textured and moderately fine textured water-worked glacial till.

In a representative profile the surface layer is black clay loam about 8 inches thick. The subsoil, about 13 inches thick, is very dark grayish brown clay in the upper part and dark grayish brown clay loam in the lower part. The underlying material, to a depth of 32 inches, is light brownish gray clay loam mottled with reddish brown. Below this is light yellowish brown clay loam mottled with gray over light olive brown loam mottled with yellowish red.

Permeability is moderately slow in the surface layer and subsoil and slow in the underlying material. The available water capacity, organic-matter content, and fertility are high. These soils have a seasonal water table 3 to 4 feet below the surface.

Doran soils are well suited to farming and to trees. All the acreage is used for crops. The limitations for many nonfarm uses are moderate and severe.

Representative profile of Doran clay loam, in a cultivated field, 339 feet north and 147 feet east of the southwest corner of sec. 35, T. 145 N., R. 52 W.

Ap—0 to 8 inches, black (10YR 2/1) clay loam, very dark gray (10YR 3/1) when dry; moderate fine granular structure; hard, friable, sticky and plastic; few roots and pores; neutral; abrupt smooth boundary.

B21t—8 to 16 inches, very dark grayish brown (10YR 3/2) clay, very dark gray (10YR 3/1) coatings on peds, grayish brown (10YR 5/2) when dry; strong medium prismatic structure parting to moderate fine blocky; very hard, firm, very sticky and very plastic; common roots and pores; clay films on prisms and blocks; neutral; gradual smooth boundary.

B22t—16 to 21 inches, dark grayish brown (2.5Y 4/2) clay loam, light brownish gray (2.5Y 6/2) when dry; few fine faint brown mottles; moderate medium prismatic structure parting to moderate fine blocky; very hard, firm, very sticky and very plastic; common roots and pores; clay films on prisms and blocks; neutral; clear smooth boundary.

C1ca—21 to 32 inches, light brownish gray (2.5Y 6/2) clay loam, light gray (2.5Y 7/2) when dry; few medium distinct reddish brown (5YR 4/3) mottles; weak coarse prismatic structure parting to moderate fine granular; slightly hard, friable, sticky and plastic; few roots and common pores; violently effervescent; mildly alkaline; gradual wavy boundary.

C2—32 to 44 inches, light yellowish brown (2.5Y 6/4) clay loam, light gray (2.5Y 7/2) when dry; common medium distinct gray (5Y 6/1) mottles; weak coarse prismatic structure parting to weak medium granular; hard, firm, sticky and plastic; few roots and pores; common gypsum crystals; strongly effervescent; mildly alkaline; gradual wavy boundary.

C3—44 to 60 inches, light olive brown (2.5Y 5/4) loam, pale yellow (2.5Y 7/4) when dry; many coarse prominent yellowish red (5YR 5/6) mottles; massive; slightly hard, friable, slightly sticky and slightly plastic; strongly effervescent; mildly alkaline.

The solum is 12 to 24 inches thick. The A horizon is 6 to 9 inches thick and is black or very dark gray clay loam or silty clay loam. The B horizon is 6 to 14 inches thick and is dark gray to very dark grayish brown. In some places the lower part of the B horizon is calcareous and has faint or distinct mottles. Pebbles and stones are common throughout the soil.

Doran soils are near the Hamerly, Tonka, and Viking soils. Unlike Hamerly soils, they lack a layer where lime has accumulated within 16 inches of the surface. They are better drained than Tonka soils and, unlike those soils, lack a platy A2 horizon. They are better drained and contain less clay than Viking soils.

Do—Doran clay loam. This nearly level soil is on plane and slightly concave slopes between the beaches. The surface layer is clay loam in most areas, but it is silty clay loam in a few areas. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Hamerly clay loam, which makes up not more than 10 percent of this mapping unit, and Tonka silt loam, which makes up not more than 5 percent. The Hamerly soil is on convex slopes, and the Tonka soil is in shallow depressions. Small wet areas and a few small areas that are steep and have short slopes are indicated by a spot symbol on the soil map.

In many areas a few small to large stones interfere with tillage. Soil blowing is a slight hazard. Runoff is slow.

All areas of this soil are used for crops. This soil is

well suited to farming and to trees. Conserving moisture, maintaining tilth, and removing stones and excess water are the main concerns of management. Capability unit IIc–6; windbreak suitability group 1.

Dovray Series

The Dovray series consists of deep, poorly drained and very poorly drained, nearly level soils. These soils are in shallow to deep depressions, swales, and drainageways on the glacial lake plain. They formed in fine textured glacial lacustrine deposits.

In a representative profile the surface layer is black silty clay about 20 inches thick. The subsoil, about 28 inches thick, is very dark gray clay in the upper part and dark gray clay in the lower part. The underlying material is olive gray clay mottled with yellowish brown.

Permeability is very slow, and the available water capacity is high. The organic-matter content and fertility are high. These soils have a seasonal high water table that ranges from 0 to 3 feet below the surface.

Dovray soils are fairly well suited to farming and well suited to trees if excess water is removed. Most areas of these soils are used for crops, but some areas are in grass. The limitations for most nonfarm uses are severe.

Representative profile of Dovray silty clay, in a cultivated field, 648 feet south and 72 feet west of the northeast corner of sec. 35, T. 114 N., R. 52 W.

Ap—0 to 7 inches, black (10YR 2/1) silty clay, very dark gray (10YR 3/1) when dry; moderate fine granular structure; very hard, firm, very sticky and very plastic; common roots and pores; neutral; abrupt smooth boundary.

A12—7 to 20 inches, black (10YR 2/1) silty clay, very dark gray (10YR 3/1) when dry; moderate very fine blocky structure; very hard, firm, very sticky and very plastic; common roots and pores; neutral; clear irregular boundary.

B21g—20 to 30 inches, very dark gray (5Y 3/1) clay, gray (5Y 5/1) when dry; moderate very fine blocky structure; very hard, very firm, very sticky and very plastic; few roots and common pores; slightly effervescent; neutral; gradual wavy boundary.

B22g—30 to 48 inches, dark gray (5Y 4/1) clay, gray (5Y 5/1) when dry; moderate very fine blocky structure; very hard, very firm, very sticky and very plastic; slightly effervescent; mildly alkaline; gradual wavy boundary.

Cg—48 to 60 inches, olive gray (5Y 4/2) clay, light gray (5Y 7/2) when dry; few fine distinct yellowish brown mottles; massive; very hard, very firm, very sticky and very plastic; strongly effervescent; mildly alkaline.

The solum ranges from 28 to 60 inches in thickness. The A horizon ranges from 10 to 30 inches in thickness and is black or very dark gray. It is mainly silty clay or clay, but in a few places it is heavy silty clay loam in the upper part. The B horizon ranges from 18 to 30 inches in thickness and is very dark gray to dark gray clay or silty clay. The C horizon is light gray to olive gray silty clay or clay. It has few to many, distinct or prominent mottles. In places the upper part of this horizon has a layer where lime has accumulated.

Dovray soils formed in material similar to that in which the Enloe, Fargo, and Hegne soils formed. They lack a platy subsurface layer, which Enloe soils have. They have a thicker solum than Fargo soils. Unlike Hegne soils, Dovray soils lack a layer where lime has accumulated within 16 inches of the surface.

Dv—Dovray silty clay. This soil is in shallow to deep depressions, swales, and drainageways on the glacial lake plain. It has the profile described as representative of the series. The surface layer is silty clay in most areas, but it is clay or silty clay loam in a few small areas. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Fargo silty clay, which makes up not more than 12 percent of this mapping unit, and Grano silty clay, which makes up not more than 8 percent. The Fargo soil is in the higher areas, and the Grano soil is on the rims of depressions and the edges of drainageways. A few small saline areas are indicated by a spot symbol on the soil map.

Runoff is ponded. Water ponds in spring and during periods of heavy rainfall. A seasonal water table is at or near the surface in spring and during periods of heavy rainfall.

Most areas of this soil are used for crops, but some areas are in grass that is left for wildlife food and cover, cut for hay, or used for pasture. This soil is fairly well suited to farming and well suited to trees if excess water is removed. Removing excess water and maintaining tilth are the main concerns of management. Capability unit IIIw–4; windbreak suitability group 2.

Eckman Series

The Eckman series consists of deep, well drained, gently sloping soils. These soils are on beaches and breaks along drainageways and streams on the delta and between the beaches. They formed in medium textured glacial melt-water deposits.

In a representative profile the surface layer is black silt loam about 7 inches thick. The subsoil is dark grayish brown silt loam about 8 inches thick. The underlying material, to a depth of 60 inches, is silt loam. The upper 6 inches is light brownish gray, the next 12 inches is light olive brown and the lower 27 inches is olive brown and mottled with gray and yellowish brown.

Permeability is moderate, and the available water capacity is high. The organic-matter content is high, and fertility is medium. These soils have a deep water table.

Eckman soils are well suited to farming and to trees. Nearly all areas of these soils are used for crops, but a few areas are in grass. The limitations for many nonfarm uses are slight and moderate.

Eckman soils are mapped only in complex with Gardena soils.

Representative profile of Eckman silt loam, in an area of Gardena-Eckman silt loams, 3 to 6 percent slopes, in a cultivated field, 2,390 feet north and 2,380 feet west of the southeast corner of sec. 5, T. 148 N., R. 53 W.

Ap—0 to 7 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) when dry; weak medium granular structure; soft, very friable, slightly sticky and slightly plastic; common roots and pores; neutral; abrupt smooth boundary.

B2—7 to 15 inches, dark grayish brown (10YR 4/2) silt loam, grayish brown (10YR 5/2) when dry; weak medium prismatic structure parting to weak medium blocky; soft, very friable, slightly sticky and

slightly plastic; common roots and many pores; neutral; clear smooth boundary.

C1ca—15 to 21 inches, light brownish gray (2.5Y 6/2) silt loam, light gray (2.5Y 7/2) when dry; weak medium prismatic structure parting to weak medium blocky; soft, very friable, slightly sticky and slightly plastic; few roots and many pores; violently effervescent; mildly alkaline; gradual smooth boundary.

C2—21 to 33 inches, light olive brown (2.5Y 5/4) silt loam, pale yellow (2.5Y 7/4) when dry; weak medium prismatic structure; soft, very friable, slightly sticky and slightly plastic; few roots and common pores; strongly effervescent; mildly alkaline; gradual wavy boundary.

C3—33 to 60 inches, olive brown (2.5Y 4/4) silt loam, pale yellow (2.5Y 7/4) when dry; few medium distinct gray (5Y 5/1) mottles and common medium distinct yellowish brown (10YR 5/6) mottles; weak coarse subangular blocky structure; soft, very friable, slightly sticky and slightly plastic; strongly effervescent; mildly alkaline.

The solum ranges from 15 to 24 inches in thickness. The soil is dominantly silt loam, but the range includes loam and very fine sandy loam. The A horizon ranges from 7 to 10 inches in thickness and is black or very dark gray. The B horizon ranges from 8 to 14 inches in thickness and is dark gray to grayish brown. The C horizon commonly is silt loam, loam, or very fine sandy loam, but below a depth of 40 inches, the texture is fine sandy loam, silty clay loam, or silty clay in a few places.

Eckman soils formed in material similar to that in which the Gardena, Glyndon, and Zell soils formed. They have a thinner solum and are better drained than Gardena soils. They are better drained than Glyndon soils. They have a thicker solum than Zell soils.

Egeland Series

The Egeland series consists of deep, well drained, nearly level and gently sloping soils. These soils are on beaches and breaks to drainageways and streams on the delta, between the beaches, and on the glacial till plain. They formed in moderately coarse textured and coarse textured glacial melt-water deposits.

In a representative profile the surface layer is black fine sandy loam about 8 inches thick. The subsoil is fine sandy loam about 29 inches thick. The upper part is very dark grayish brown, the middle part is dark grayish brown, and the lower part is olive brown. The underlying material is light olive brown loamy fine sand that is mottled with brown and light gray in the lower part.

Permeability is moderately rapid, and the available water capacity is moderate. The organic-matter content is high, and fertility is medium. These soils have a deep water table.

Egeland soils are fairly well suited to farming in most areas and are well suited to trees. Nearly all areas of these soils are used for crops, but a few areas are in grass. The limitations for most nonfarm uses are slight or severe.

Representative profile of Egeland fine sandy loam, in an area of Egeland-Embden fine sandy loams, 1 to 3 percent slopes, in a cultivated field, 440 feet south and 1,220 feet west of the northeast corner of sec. 4, T. 148 N., R. 53.

Ap—0 to 8 inches, black (10YR 2/1) fine sandy loam, dark gray (10YR 4/1) when dry; weak medium granular structure; soft, very friable, slightly sticky and slightly plastic; many roots and pores; neutral; abrupt smooth boundary.

B21—8 to 14 inches, very dark grayish brown (10YR 3/2) fine sandy loam, grayish brown (10YR 5/2) when dry; weak coarse prismatic structure parting to weak coarse subangular blocky; soft, very friable, slightly sticky and slightly plastic; common roots and pores; neutral; clear wavy boundary.

B22—14 to 22 inches, dark grayish brown (10YR 4/2) fine sandy loam, light brownish gray (10YR 6/2) when dry; weak coarse prismatic structure parting to weak coarse subangular blocky; soft, very friable, slightly sticky and slightly plastic; common roots and pores; neutral; gradual wavy boundary.

B3—22 to 37 inches, olive brown (2.5Y 4/4) fine sandy loam, light yellowish brown (2.5Y 6/4) when dry; weak coarse prismatic structure parting to weak coarse subangular blocky; soft, very friable, slightly sticky and slightly plastic; few roots and pores; neutral; gradual wavy boundary.

C1—37 to 54 inches, light olive brown (2.5Y 5/4) loamy fine sand, light yellowish brown (2.5Y 6/4) when dry; weak coarse subangular blocky structure; soft, very friable, slightly sticky and slightly plastic; strongly effervescent; mildly alkaline; gradual wavy boundary.

C2—54 to 60 inches, light olive brown (2.5Y 5/4) loamy fine sand, pale yellow (2.5Y 7/4) when dry; few medium faint brown (10YR 4/3) mottles and many medium distinct light gray (10YR 7/1) mottles; single grained; soft, loose, nonsticky and nonplastic; strongly effervescent; mildly alkaline.

The solum is 20 to 38 inches thick. The A horizon is 6 to 8 inches thick. It is black or very dark gray loam, sandy loam, or fine sandy loam. The B horizon is 14 to 30 inches thick and is fine sandy loam or sandy loam. The C horizon is sandy loam or fine sandy loam at a depth of less than 30 inches. Between a depth of 30 and 40 inches, it ranges from sand to fine sandy loam, but it is dominantly fine sandy loam. At a depth of more than 40 inches, it ranges from sand to silt loam, but it is commonly loamy fine sand, sandy loam, or fine sandy loam.

Egeland soils formed in material similar to that in which the Embden, Tiffany, and Wyndmere soils formed. They have a thinner A horizon than Embden soils. They are better drained than Tiffany soils, and they are not mottled so near the surface. Egeland soils are better drained than Wyndmere soils, and they lack a layer where lime has accumulated within 16 inches of the surface.

EdA—Egeland loam, 1 to 3 percent slopes. This nearly level soil is on beaches on the delta. It has a profile similar to the one described as representative of the series, but the surface layer is loam.

Included with this soil in mapping are some areas of Eckman loam, which makes up not more than 15 percent of this mapping unit, and Embden loam, Gardena loam, or both, which make up not more than 10 percent. The Eckman soil is on slightly convex side slopes, and the Embden or Gardena soils are on plane side slopes. A few small wet areas are indicated by a spot symbol on the soil map.

Runoff is slow. Soil blowing is a moderate hazard.

All areas of this soil are used for crops. This soil is well suited to farming and to trees. Controlling soil blowing and conserving moisture are the main concerns of management. Capability unit IIe–5; windbreak suitability group 5.

EgA—Egeland-Embden fine sandy loams, 1 to 3 percent slopes. The soils of this complex are nearly level and are on beaches on the delta and between the beaches. The Egeland soil is on plane and convex side slopes, and the Embden soil is on plane side slopes. This complex is at least 55 percent Egeland fine sandy loam and about 35 percent Embden fine sandy loam.

In a few small areas these soils have a surface layer

of sandy loam instead of fine sandy loam. The Egeland soil has the profile described as representative of the series.

Included with this complex in mapping are some areas of Tiffany fine sandy loam, which makes up not more than 10 percent of this mapping unit. This soil is in depressions, swales, or drainageways. Small wet areas are indicated by a spot symbol on the soil map.

Runoff is slow. Soil blowing is a severe hazard.

Nearly all areas of this complex are used for crops, but a few small areas are in grass that is cut for hay or used for pasture. This complex is fairly well suited to farming and well suited to trees. Controlling soil blowing and conserving moisture are the main concerns of management. Capability unit IIIe–3; Egeland part in windbreak suitability group 5, Embden part in windbreak suitability group 1.

EgB—Egeland-Embden fine sandy loams, 3 to 6 percent slopes. The soils of this complex are gently sloping and are on beaches, on breaks along drainageways and streams, and in areas on the delta and glacial till plain. The Egeland soil is on convex side slopes, and the Embden soil is on plane side slopes. This complex is at least 65 percent Egeland fine sandy loam and about 25 percent Embden fine sandy loam.

In a few places these soils have a surface layer of sandy loam instead of fine sandy loam.

Included with this soil in mapping are some areas of Maddock sandy loam, which makes up not more than 10 percent of this mapping unit. This soil is on the crests of beaches and breaks.

Runoff is medium. The hazard of water erosion is moderate, and the hazard of soil blowing is severe.

Nearly all areas of this complex are used for crops, but a few small areas are in grass that is cut for hay or used for pasture. This complex is fairly well suited to farming and well suited to trees. Controlling soil blowing and water erosion and conserving moisture are the main concerns of management. Capability unit IIIe–3; Egeland part in windbreak suitability group 5, Embden part in windbreak suitability group 1.

Embden Series

The Embden series consists of deep, nearly level and gently sloping, moderately well drained soils. These soils are on broad to narrow beaches, on breaks to drainageways and streams, and in broad areas on the delta and between the beaches. They formed in moderately coarse textured glacial melt-water deposits.

In a representative profile the surface layer is black fine sandy loam about 19 inches thick. The subsoil is very dark grayish brown fine sandy loam about 8 inches thick. The underlying material is fine sandy loam mottled with yellowish brown. The upper part is dark grayish brown, and the lower part is olive brown.

Permeability is moderately rapid, and the available water capacity is moderate. The organic-matter content and fertility are high. In most years these soils have a deep water table.

Embden soils are fairly well suited to farming in most areas and are well suited to trees. Nearly all areas of these soils are used for crops, but a few areas are in grass. The limitations for many nonfarm uses range from slight to severe.

Representative profile of Embden fine sandy loam, in a cultivated field, 165 feet west and 1,010 feet north of the southeast corner of sec. 33, T. 144 N., R. 53 W.

Ap—0 to 8 inches, black (10YR 2/1) fine sandy loam, dark gray (10YR 4/1) when dry; weak fine granular structure; soft, very friable, slightly sticky and slightly plastic; common roots and pores; slightly acid; abrupt smooth boundary.

A12—8 to 19 inches, black (10YR 2/1) fine sandy loam, dark gray (10YR 4/1) when dry; weak medium blocky structure parting to weak fine granular; soft, very friable, slightly sticky and slightly plastic; common roots and pores; slightly acid; clear wavy boundary.

B2—19 to 27 inches, very dark grayish brown (10YR 3/2) fine sandy loam, grayish brown (10YR 5/2) when dry; weak medium prismatic structure parting to moderate medium blocky; soft, very friable, slightly sticky and slightly plastic; few roots and common pores; neutral; gradual wavy boundary.

C1—27 to 43 inches, dark grayish brown (2.5Y 4/2) fine sandy loam, light brownish gray (2.5Y 6/2) when dry; common medium distinct yellowish brown (10YR 5/6) mottles; weak coarse subangular blocky structure; soft, very friable, slightly sticky and slightly plastic; strongly effervescent; mildly alkaline; gradual wavy boundary.

C2—43 to 60 inches, olive brown (2.5Y 4/4) fine sandy loam, light gray (2.5Y 7/2) when dry; many medium distinct yellowish brown (10YR 5/6) mottles; massive; soft, very friable, slightly sticky and slightly plastic; strongly effervescent; mildly alkaline.

The solum ranges from 20 to 36 inches in thickness. The A horizon ranges from 12 to 22 inches in thickness and is black or very dark gray. It is dominantly fine sandy loam and very fine sandy loam, but it ranges from loam and sandy loam. It is neutral or slightly acid. The B horizon ranges from 8 to 16 inches in thickness. It is very dark brown or very dark grayish brown fine sandy loam or sandy loam. In places the lower part has few or common faint mottles. The C horizon is commonly fine sandy loam or loamy fine sand, but below a depth of 40 inches in a few places, it is fine sand, silt loam, clay loam, silty clay loam, or silty clay. It is mildly alkaline or moderately alkaline. A stone line is at a depth of 40 to 60 inches in some places.

Embden soils formed in material similar to that in which the Egeland, Tiffany, and Wyndmere soils formed. They are darker colored to a greater depth than Egeland soils. They are better drained than Tiffany soils. Unlike Wyndmere soils, Embden soils lack a layer that has an accumulation of lime within 16 inches of the surface.

Em—Embden fine sandy loam. This nearly level soil is on broad to narrow beaches and in broad areas on the delta and between the beaches. It has the profile described as representative of the series. The surface layer is fine sandy loam in most places, but it is sandy loam in a few places. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Tiffany fine sandy loam, which makes up not more than 12 percent of this mapping unit, and Wyndmere fine sandy loam, which makes up not more than 8 percent. The Tiffany soil is in shallow depressions and swales, and the Wyndmere soil is on slightly convex side slopes. Also included are a few areas where a stone line is within 3 feet of the surface. These areas are mainly on Hillsboro beach. A few small wet areas are indicated by a spot symbol on the soil map.

Runoff is slow. Soil blowing is a severe hazard.

Nearly all areas of this soil are used for crops, but a few small areas are in grass that is cut for hay or

used for pasture. This soil is fairly well suited to farming and well suited to trees. Controlling soil blowing and conserving moisture are the main concerns of management. Capability unit IIIe–3; windbreak suitability group 1.

En—Embden very fine sandy loam. This nearly level soil is on beaches and in broad areas on the delta and between the beaches. It has a profile similar to the one described as representative of the series, but the surface layer is very fine sandy loam at a depth of 6 to 12 inches. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Tiffany loam, which makes up not more than 10 percent of this mapping unit, and Wyndmere loam, which makes up not more than 5 percent. The Tiffany soil is in shallow depressions and swales, and the Wyndmere soil is on slightly convex side slopes. Also included are a few areas where a stone line is within 3 feet of the surface. These areas are mainly on Hillsboro beach. Small wet areas and a few areas that are steep and have short slopes are indicated by spot symbols on the soil map.

Runoff is slow. Soil blowing is a moderate hazard. The available water capacity is moderate.

All areas of this soil are used for crops. This soil is well suited to farming and to trees. Controlling soil blowing and conserving moisture are the main concerns of management. Capability unit IIe–5; windbreak suitability group 1.

Emrick Series

The Emrick series consists of deep, moderately well drained, nearly level and undulating soils. These soils are in broad areas between the beaches and on the glacial till plain. They formed in medium textured water-worked glacial till.

In a representative profile the surface layer is black loam about 9 inches thick. The subsoil is loam about 23 inches thick. The upper part is very dark grayish brown, and the lower part is dark grayish brown. The underlying material, to a depth of 40 inches, is grayish brown loam that has an accumulation of lime. Below this is light olive brown loam mottled with yellowish red.

Permeability is moderate, and the available water capacity is high. The organic-matter content and fertility are high. These soils have a deep water table.

Emrick soils are well suited to farming and to trees. Most areas of these soils are used for crops, but a few areas are in grass. The limitations for nonfarm uses range from slight to severe.

Representative profile of Emrick loam, in an area of Emrick-Heimdal loams, 1 to 3 percent slopes, in a cultivated field, 1,927 feet north and 90 feet east of the southwest corner of sec. 31, T. 144 N., R. 53 W.

Ap—0 to 6 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) when dry; weak medium subangular blocky structure parting to weak medium granular; slightly hard, friable, slightly sticky and slightly plastic; many roots and pores; slightly acid; abrupt smooth boundary.

A12—6 to 9 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) when dry; weak medium subangular blocky structure parting to weak medium granular; slightly hard, friable, slightly sticky and slightly plastic; many roots and pores; slightly acid; clear smooth boundary.

B21—9 to 20 inches, very dark grayish brown (10YR 3/2) loam, grayish brown (10YR 5/2) when dry; moderate medium prismatic structure parting to moderate medium blocky; slightly hard, friable, slightly sticky and slightly plastic; common roots and many pores; slightly acid; clear smooth boundary.

B22—20 to 32 inches, dark grayish brown (10YR 4/2) loam, brown (10YR 5/3) when dry; moderate medium prismatic structure parting to moderate medium blocky; slightly hard, friable, slightly sticky and slightly plastic; common roots and many pores; neutral; gradual wavy boundary.

C1ca—32 to 40 inches, grayish brown (2.5Y 5/2) loam, light gray (2.5Y 7/2) when dry; weak medium prismatic structure; slightly hard, friable, slightly sticky and slightly plastic; few roots and pores; violently effervescent; mildly alkaline; gradual wavy boundary.

C2—40 to 60 inches, light olive brown (2.5Y 5/4) loam, light yellowish brown (2.5Y 6/4) when dry; common medium distinct yellowish red (5YR 4/6) mottles; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; strongly effervescent; mildly alkaline.

The solum ranges from 16 to 36 inches in thickness. This soil is 2 to 10 percent rock fragments. The A horizon ranges from 9 to 13 inches in thickness and is black or very dark gray. It is dominantly loam, but it is silt loam or very fine sandy loam in a few places. This horizon is slightly acid or neutral. The B horizon ranges from 7 to 23 inches in thickness. It is very dark grayish brown to brown loam or silt loam. The C horizon is mildly alkaline or moderately alkaline. It has few to many, faint to prominent mottles. The Cca horizon is loam or silt loam. A thin layer of stones and pebbles is in this horizon in places.

In Traill County Emrick loam has more silt and less sand than is defined as the range for the series. This difference does not alter the usefulness or behavior of the soil.

Emrick soils are near the Esmond, Heimdal, and Lankin soils. They have a thicker solum than Esmond soils. They are darker colored to a greater depth than Heimdal soils. They contain less clay than Lankin soils.

Eo—Emrick loam. This nearly level soil is in broad areas between the beaches. It is on plane and slightly concave slopes. It has a profile similar to the one described as representative of the series, but it contains more silt and less sand. The surface layer is loam in most places, but it is silt loam in a few areas. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Bohnsack loam, which makes up not more than 15 percent of this mapping unit, and Tiffany loam, which makes up not more than 5 percent. The Bohnsack soil is on slightly convex slopes, and the Tiffany soil is in shallow depressions and swales. Small wet areas, a few small areas that are steep and have short slopes, and a few small saline areas are indicated by spot symbols on the soil map.

Runoff is slow. Soil blowing is a moderate hazard. In some areas small to large stones interfere with tillage.

Most areas of these soils are used for crops, but a few small areas are in grass that is cut for hay or used for pasture. This soil is well suited to farming and to trees. Controlling soil blowing and conserving moisture are the main concerns of management. Capability unit IIe–5; windbreak suitability group 1.

EpA—Emrick-Heimdal loams, 1 to 3 percent slopes.

The soils of this complex are nearly level and are in areas on the glacial till plain. Slopes generally are short. The Emrick soil is on plane and concave side slopes, and the Heimdal soil is on slightly convex side slopes. This complex is about 50 percent Emrick loam and about 37 percent Heimdal loam.

The Emrick soil has the profile described as representative of the series.

Included with this complex in mapping are some areas of Hamerly loam, which makes up not more than 8 percent of this mapping unit, and Tonka silt loam, which makes up not more than 5 percent. The Hamerly soil is on slightly convex lower side slopes, and the Tonka soil is in depressions. Small wet areas are indicated by a spot symbol on the soil map.

Runoff is slow on the Emrick soil and medium on the Heimdal soil. Soil blowing is a moderate hazard. In a few areas stones interfere with tillage.

Nearly all areas of this complex are used for crops, but a few areas are in grass that is cut for hay or used for pasture. This complex is well suited to farming and to trees. Controlling soil blowing and conserving moisture are the main concerns of management. Capability unit IIe–5; Emrick part in windbreak suitability group 1, Heimdal part in windbreak suitability group 3.

Enloe Series

The Enloe series consists of deep, poorly drained, nearly level soils. These soils are in shallow depressions on the glacial lake plain. They formed in fine textured glacial lacustrine deposits.

In a representative profile the surface layer is black silty clay loam about 10 inches thick. The subsurface layer, about 4 inches thick, is dark gray silty clay loam mottled with yellowish brown. The subsoil is clay about 24 inches thick. The upper part is very dark gray, and the lower part is dark gray. The underlying material is olive gray silty clay.

Permeability is slow, and the available water capacity is high. The organic-matter content and fertility are high. These soils have a seasonal water table 1 to 3 feet below the surface.

Enloe soils are well suited to farming and to trees if excess water is removed. All areas of these soils are used for crops. The limitations for most nonfarm uses are severe.

Enloe soils are mapped only in complex with Fargo and Hegne soils.

Representative profile of Enloe silty clay loam, in an area of Fargo-Enloe silty clay loams, in a cultivated field, 381 feet south and 1,371 feet west of the northeast corner of sec. 7, T. 144 N., R. 50 W.

Ap—0 to 7 inches, black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) when dry; weak fine granular structure; hard, friable, sticky and plastic; common roots and pores; slightly acid; abrupt smooth boundary.

A12—7 to 10 inches, black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) when dry; weak coarse blocky structure; hard, friable, sticky and plastic; common roots and pores; slightly acid; clear smooth boundary.

A2—10 to 14 inches, dark gray (10YR 4/1) silty clay loam, light gray (10YR 6/1) when dry; common medium faint yellowish brown (10YR 5/6) mottles; weak medium prismatic structure parting to moderate medium platy; slightly sticky and slightly plastic; common roots and many pores; slightly acid; clear wavy boundary.

B21t—14 to 22 inches, very dark gray (5Y 3/1) clay, dark gray (5Y 4/1) when dry; weak coarse prismatic structure parting to strong fine blocky; very hard, firm, very sticky and very plastic; few roots and common pores; continuous clay films on blocks; neutral; gradual wavy boundary.

B22t—22 to 38 inches, dark gray (5Y 4/1) clay, gray (5Y 5/1) when dry; weak coarse prismatic structure parting to strong very fine blocky; very hard, firm, very sticky and very plastic; few roots and pores; continuous clay films on blocks; neutral; gradual wavy boundary.

Cg—38 to 60 inches, olive gray (5Y 5/2) silty clay, light olive gray (5Y 6/2) when dry; moderate very fine blocky structure; very hard, firm, very sticky and very plastic; slightly effervescent; mildly alkaline.

The solum ranges from 24 to 48 inches in thickness. The A1 horizon, 8 to 14 inches thick, is black or very dark gray silty clay loam or silty clay. This horizon is slightly acid or neutral. The A2 horizon, 4 to 8 inches thick, is dark gray or gray silty clay or silty clay loam. It is slightly acid or neutral. In most places the A2 horizon has faint or distinct mottles. The B horizon ranges from 12 to 24 inches in thickness and is black to dark olive gray. The C horizon is clay or silty clay.

Enloe soils formed in material similar to that in which the Dovray, Fargo, and Hegne soils formed. They have a platy A2 horizon, which Dovray soils lack. They have a thicker solum than Fargo soils. Unlike Hegne soils, Enloe soils lack a layer of lime accumulation within 16 inches of the surface.

Esmond Series

The Esmond series consists of deep, well drained, gently rolling soils. These soils are on short, convex side slopes on the glacial till plain. They formed in medium textured and moderately coarse textured water-worked glacial till.

In a representative profile the surface layer is very dark gray loam about 7 inches thick. The underlying material, to a depth of 15 inches, is grayish brown loam, and to a depth of 46 inches, it is light olive brown loam mottled with yellowish brown. Below this is light yellowish brown loamy sand.

Permeability is moderate, and the available water capacity is high. The organic-matter content is moderate, and fertility is low. These soils have a deep water table.

Esmond soils are fairly well suited to farming and to trees. Nearly all areas of these soils are used for crops, but a few areas are in grass. The limitations for many nonfarm uses are slight and moderate.

Esmond soils are mapped only in complex with Heimdal soils.

Representative profile of Esmond loam, in an area of Heimdal-Esmond loams, 6 to 9 percent slopes, in a cultivated field, 201 feet north and 228 feet east of the southwest corner of sec. 19, T. 144 N., R. 53 W.

Ap—0 to 7 inches, very dark gray (10YR 3/1) loam, dark gray (10YR 4/1) when dry; weak medium subangular blocky structure parting to weak fine granular; soft, very friable, slightly sticky and slightly plastic; common roots and pores; slightly effervescent; neutral; abrupt smooth boundary.

C1ca—7 to 15 inches, grayish brown (2.5Y 5/2) loam, light gray (2.5Y 7/2) when dry; weak medium blocky structure; soft, very friable, slightly sticky and slightly plastic; common roots and pores;

strongly effervescent; mildly alkaline; gradual wavy boundary.

C2—15 to 46 inches, light olive brown (2.5Y 5/4) loam, pale yellow (2.5Y 7/4) when dry; few fine distinct yellowish brown mottles; weak medium blocky structure parting to weak medium platy; soft, very friable, slightly sticky and slightly plastic; few roots and common pores; slightly effervescent; mildly alkaline; gradual wavy boundary.

IIC3—46 to 60 inches, light yellowish brown (2.5Y 6/4) loamy sand, light gray (2.5Y 7/2) when dry; single grained; loose, nonsticky and nonplastic; slightly effervescent; mildly alkaline.

The A horizon ranges from 5 to 9 inches in thickness. It is black or very dark gray loam or sandy loam. The Cca horizon is loam or sandy loam. The C horizon is mainly loam, sandy loam, or silt loam, but scattered pockets of clay loam and loamy sand are at a depth of more than 40 inches in some places. The soil is 1 to 5 percent coarse fragments.

Esmond soils are near the Emrick, Heimdal, and Tonka soils. They have a thinner A horizon than Emrick soils, but they lack a B horizon. They lack a B horizon, which Heimdal soils have. They contain less clay than Tonka soils.

Fairdale Series

The Fairdale series consists of deep, moderately well drained, nearly level soils. These soils are on flood plains on bottom lands along streams. They formed in medium textured recent alluvial deposits.

In a representative profile the surface layer is finely stratified very dark grayish brown silt loam about 10 inches thick. The underlying material, to a depth of 37 inches, is dark grayish brown silt loam. Below this is a buried layer of very dark gray silt loam about 5 inches thick. The lower part of the underlying material is dark grayish brown silt loam.

Permeability is moderate, and the available water capacity is high. The organic-matter content is moderate, and fertility is high. These soils have a deep water table and are subject to flooding by streams.

Fairdale soils are well suited to farming and to trees. Most areas of these soils are used for crops. Some areas are in native woodland, and a few areas are in grass. The limitations for many nonfarm uses are moderate and severe.

Representative profile of Fairdale silt loam, 1 to 3 percent slopes, in a cultivated field, 140 feet east and 1,080 feet north of the southwest corner of sec. 17, T. 146 N., R. 51 W.

Ap—0 to 7 inches, very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) when dry; weak medium subangular blocky structure parting to weak fine granular; slightly hard, very friable, slightly sticky and slightly plastic; many roots and common pores; strongly effervescent; mildly alkaline; abrupt smooth boundary.

A12—7 to 10 inches, very dark grayish brown (10YR 3/2) finely stratified silt loam, grayish brown (10YR 5/2) when dry; weak medium blocky structure parting to weak fine granular; slightly hard, very friable, slightly sticky and slightly plastic; common roots and pores; strongly effervescent; mildly alkaline; clear smooth boundary.

C1—10 to 37 inches, dark grayish brown (10YR 4/2) finely stratified silt loam, light brownish gray (10YR 6/2) when dry; weak coarse prismatic structure parting to weak fine granular; slightly hard, very friable, slightly sticky and slightly plastic; few roots and common pores; strongly effervescent; mildly alkaline; clear smooth boundary.

A1b—37 to 42 inches, very dark gray (10YR 3/1) silt loam, gray (10YR 5/1) when dry; weak fine granular structure; silghtly hard, very friable, slightly sticky and slightly plastic; few roots and common pores; strongly effervescent; mildly alkaline; gradual smooth boundary.

C2—42 to 60 inches, dark grayish brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) when dry; weak medium subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; strongly effervescent; mildly alkaline.

These soils formed in stratified alluvium. The strata range from less than 1 inch to more than 8 inches in thickness and are fine sandy loam, silt loam, or silty clay loam. The A horizon is very dark brown, very dark gray, or very dark grayish brown. One or more buried horizons are within 60 inches of the surface. Faint or distinct mottles are below a depth of 20 inches in some places.

Fairdale soils are in positions similar to those of the Cashel, Lamoure, and La Prairie soils. They contain more sand and less clay than Cashel soils. They are better drained than Lamoure soils. They have a thinner and lighter colored A horizon than La Prairie soils.

FaA—Fairdale silt loam, 1 to 3 percent slopes. This nearly level soil is on flood plains on bottom lands along streams. It has the profile described as representative of the series.

Included with this soil in mapping are some areas of La Prairie silt loam, which makes up not more than 14 percent of this mapping unit, and Lamoure silt loam, which makes up not more than 4 percent. The La Prairie soil is in higher areas, and the Lamoure soil is in abandoned stream channels. Also included are small areas that have slopes of 3 to 6 percent. A few small saline areas and small areas that are steep and have short slopes are indicated by spot symbols on the soil map.

This soil is subject to flooding from overflowing streams in spring during periods when rainfall is heavy and snow melts rapidly. Runoff is slow.

Most areas of this soil are used for crops, but some areas are in native woodland, and a few areas are in grass that is cut for hay or used for pasture. Some areas of native woodland are used for pasture. This soil is well suited to farming and to trees. Conserving moisture, maintaining fertility, and improving organic-matter content are the main concerns of management. Capability unit IIc–6; windbreak suitability group 1.

Fargo Series

The Fargo series consist of deep, poorly drained, nearly level soils. These soils are in shallow depressions, swales, and broad, flat areas on the glacial lake plain. They formed in fine textured glacial lacustrine deposits.

In a representative profile the surface layer is black silty clay about 8 inches thick. The subsoil is firm silty clay about 13 inches thick. The upper part is black and very dark gray, and the lower part is very dark grayish brown and very dark gray. The underlying material is silty clay. To a depth of 32 inches, it is olive gray. Below this, it is grayish brown and mottled with brown and gray, olive, and pale olive and mottled with dark yellowish brown.

Permeability is slow, and the available water capacity is high. The organic-matter content and fertility are high. These soils have a seasonal water table 3 to 5 feet below the surface.

In nearly all areas Fargo soils are well suited to farming and to trees. Nearly all areas of these soils are used for crops but a few areas are in grass. The limitations for most nonfarm uses are severe.

Representative profile of Fargo silty clay, in a cultivated field, 1,170 feet south, and 410 feet east of the northwest corner of sec. 29, T. 144 N., R. 49 W.

Ap—0 to 8 inches, black (10YR 2/1) silty clay, very dark gray (10YR 3/1) when dry; moderate fine subangular blocky structure parting to strong fine granular; very hard, blocks are friable and granules are firm, very sticky and very plastic; many fine roots and pores; neutral; abrupt smooth boundary.

B21—8 to 13 inches, black (10YR 2/1) crushed and very dark gray (10YR 3/1) rubbed silty clay, very dark gray (10YR 3/1) crushed and dark gray (10YR 4/1) rubbed when dry; moderate medium subangular blocky structure parting to strong very fine blocky; extremely hard, firm, very sticky and very plastic; many fine roots and pores; faces of peds have shiny, waxy sheen when moist; tongues of A horizon extend through this horizon; neutral; abrupt irregular boundary.

B22—13 to 21 inches, very dark grayish brown (2.5Y 3/2) and very dark gray (2.5Y 3/1) silty clay, dark grayish brown (2.5Y 4/2) and gray (2.5Y 5/1) when dry; dark grayish brown (2.5Y 4/2) crushed and rubbed, grayish brown (2.5Y 5/2) when dry; moderate coarse prismatic structure parting to strong fine and very fine blocky; extremely hard, firm, very sticky and very plastic; common fine roots and common pores; slickensides on vertical faces of peds; faces of blocks have waxy sheen when moist; tongues of A horizon extend through this horizon; slightly effervescent in lower part but tongues are not effervescent; mildly alkaline; abrupt irregular boundary.

C1gca—21 to 32 inches, olive gray (5Y 5/2) silty clay, light gray (5Y 7/2) when dry; weak medium subangular blocky structure parting to moderate fine blocky; hard, friable, sticky and plastic; few roots and common fine pores; common fine spots of segregated lime; tongues of A horizon extend into this horizon; strongly effervescent; moderately alkaline; clear wavy boundary.

C2g—32 to 48 inches, grayish brown (2.5Y 5/2) silty clay, light gray (2.5Y 7/2) when dry; common medium distinct brown (10YR 4/3) mottles and common medium distinct gray (5Y 5/1) mottles; weak medium subangular blocky structure parting to moderate very fine blocky and granular; very hard, firm, very sticky and very plastic; few fine roots and common pores; strongly effervescent; moderately alkaline; gradual wavy boundary.

C3—48 to 60 inches, olive (5Y 4/3) and pale olive (5Y 6/3) silty clay, pale olive (5Y 6/3) and pale yellow (5Y 8/3) when dry; many medium prominent dark yellowish brown (10YR 4/4) mottles; laminated fractures to moderate very fine blocky structure; very hard, firm, very sticky and very plastic; a few medium masses of segregated lime; slightly effervescent; moderately alkaline.

The solum ranges from 16 to 36 inches in thickness. The A horizon ranges from 5 to 10 inches in thickness and is clay, silty clay, or silty clay loam. The B horizon ranges from 11 to 26 inches in thickness. It is very dark gray to olive gray silty clay or clay. The C horizon has faint to prominent mottles in the lower part. It commonly is silty clay or clay, but below a depth of 40 inches, it is silt loam or silty clay loam in a few places. It has gypsum crystals in some places.

Fargo soils formed in material similar to that in which the Enloe, Hegne, and Nutley soils formed. They lack a platy A2 horizon, but Enloe soils have one. Unlike Hegne soils, Fargo soils lack a layer where lime accumulates within 16 inches of the surface. They have a thicker solum and are more poorly drained than Nutley soils.

Fb—Fargo silty clay loam. This nearly level soil is on plane and slightly concave slopes in broad areas on the glacial lake plain. It has a profile similar to the one described as representative of the series, but the surface layer is silty clay loam. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Enloe silty clay loam, which makes up not more than 4 percent of this mapping unit, and Hegne silty clay loam, which makes up not more than 12 percent. The Enloe soil is in shallow depressions, and the Hegne soil is on slightly convex slopes. Small wet areas, a few small saline areas, and small areas that are steep and have short slopes are indicated by spot symbols on the soil map.

Runoff is very slow. In a few areas water ponds in spring during periods when rainfall is heavy and snow melts rapidly.

All areas of this soil are used for crops. This soil is well suited to farming and to trees. Removing excess water and maintaining and improving tilth and permeability are the main concerns of management. Capability unit IIw–6; windbreak suitability group 1.

Fc—Fargo silty clay. This nearly level soil is in broad, flat areas on the glacial lake plain. It has the profile described as representative of the series. The surface layer is silty clay in most places, but it is clay in a few areas. Slopes range from 0 to 1 percent, but are less than 1 percent on more than 90 percent of the acreage.

Included with this soil in mapping are some areas of Enloe silty clay, which makes up not more than 5 percent of this mapping unit, and Hegne silty clay, which makes up not more than 10 percent. The Enloe soil is in shallow depressions, and the Hegne soil is on slightly convex slopes. Also included are a few areas along natural drainageways where slopes range from 1 to 3 percent. Small wet areas, small areas that are steep and have short slopes, a few small saline areas, and a few small areas of gumbo spots are indicated by spot symbols on the soil map.

Runoff is very slow. In some areas water ponds in spring and during periods of heavy rainfall. Soil blowing is a moderate hazard.

Nearly all areas of this soil are used for crops, but a few areas are in grass that is cut for hay or used for pasture. This soil is well suited to farming and to trees (fig. 10). It is difficult to till. Controlling soil blowing, removing excess water, and maintaining and improving tilth and permeability are the main concerns of management. Capability unit IIew–4; windbreak suitability group 1.

Fd—Fargo-Dovray silty clays. The soils of this complex are nearly level and are on plane and slightly concave slopes in shallow depressions and swales on the glacial lake plain. This complex is at least 55 percent Fargo silty clay and at least 30 percent Dovray silty clay. Slopes are 0 to 1 percent.

In a few areas these soils have a surface layer of clay instead of silty clay.

Included with this complex in mapping are some areas of Enloe silty clay, which makes up not more than 5 percent of this mapping unit, and Hegne silty clay, which makes up not more than 10 percent. The Enloe soil is in shallow depressions, and the Hegne soil

Figure 10.—Swathing oats on Fargo silty clay. The soil is protected from blowing by a field windbreak.

is on slightly convex slopes in depressions and along the rim of the depressions.

Runoff is very slow on the Fargo soil and ponded on the Dovray soil. Water ponds on these soils in spring and during periods of heavy rainfall. Soil blowing is a moderate hazard.

Most areas of this complex are used for crops, but a few areas are in grass that is cut for hay or used for pasture. This complex is well suited to farming and to trees if excess water is removed. It is difficult to till. Removing excess water, maintaining and improving tilth and permeability, and controlling soil blowing are the main concerns of management. Capability unit IIw–4; Fargo part in windbreak suitability group 1, Dovray part in windbreak suitability group 2.

Fe—Fargo-Enloe silty clay loams. The soils of this complex are nearly level and are in areas on the glacial lake plain. The Fargo soil is on plane slopes, and the Enloe soil is in small, shallow depressions and swales. This complex is at least 60 percent Fargo silty clay loam and about 33 percent Enloe silty clay loam. Slopes are 0 to 1 percent.

The Fargo soil has a profile similar to the one described as representative of the series, but the surface layer is silty clay loam. The Enloe soil has the profile described as representative of the series.

Included with this complex in mapping are some areas of Hegne silty clay, which makes up not more than 7 percent of this mapping unit. This soil is on slightly convex slopes. A few small areas of gumbo spots are indicated by a spot symbol on the soil map.

Runoff is very slow on the Fargo soil and ponded on the Enloe soil. Water ponds on the Enloe soil in spring and during periods of heavy rainfall. Soil blowing is a slight hazard.

All areas of this complex are used for crops. This complex is well suited to farming and to trees if excess water is removed. Removing excess water and maintaining and improving tilth and permeability are the main concerns of management. Capability unit IIw–6; Fargo part in windbreak suitability group 1, Enloe part in windbreak suitability group 2.

Fg—Fargo-Enloe silty clays. The soils of this complex are nearly level and are on plane and slightly concave slopes in small to large, shallow depressions and swales on the glacial lake plain. This complex is about 60 percent Fargo silty clay and about 35 percent Enloe silty clay. Slopes are 0 to 1 percent.

The Enloe soil has a profile similar to the one described as representative of the series, but the surface layer is silty clay. It is silty clay loam instead of silty clay in a few areas.

Included with this complex in mapping are some areas of Dovray silty clay, which makes up not more than 5 percent of this mapping unit. This soil is in the deeper parts of depressions and swales.

Runoff is very slow on the Fargo soil and ponded on the Enloe soil. Water ponds on the soils of this

complex in spring and during periods of heavy rainfall. Soil blowing is a moderate hazard.

Most areas of this complex are used for crops, but a few areas are in grass that is cut for hay or used for pasture. This complex is well suited to farming and to trees if excess water is removed. The soils are difficult to till. Removing excess water, maintaining and improving tilth and permeability, and controlling soil blowing are the main concerns of management. Capability unit IIw–4; Fargo part in windbreak suitability group 1, Enloe part in windbreak suitability group 2.

Fh—Fargo-Hegne silty clays. The soils of this complex are nearly level and are in broad areas on the glacial lake plain. The Fargo soil is on plane and concave slopes, and the Hegne soil is on plane and slightly convex slopes. This complex is about 56 percent Fargo silty clay and about 34 percent Hegne silty clay. Slopes are 0 to 1 percent. In a few small areas these soils have a surface layer of clay instead of silty clay.

Included with this complex in mapping are some areas of Enloe silty clay, which makes up not more than 10 percent of this mapping unit. This soil is in shallow depressions. Small wet areas, small areas that are steep and have short slopes, a few small areas of gumbo spots, and few small saline areas are indicated by spot symbols on the soil map.

Runoff is very slow on the Fargo soil and slow on the Hegne soil. In some areas water ponds on these soils in spring and during periods of heavy rainfall. Soil blowing is a moderate hazard.

Nearly all areas of this complex are used for crops, but a few areas are in grass that is cut for hay or used for pasture. This complex is well suited to farming and to trees. The soils are difficult to till. Controlling soil blowing, removing excess water, and maintaining and improving tilth, fertility, and permeability are the main concerns of management. Capability unit IIew–4; windbreak suitability group 1.

Fn—Fargo-Ryan silty clays. The soils of this complex are nearly level and are on plane slopes in areas of the glacial lake plain. This complex is about 52 percent Fargo silty clay and about 37 percent Ryan silty clay. Slopes are 0 to 1 percent. The Ryan soil has the profile described as representative of the series.

Included with this complex in mapping are some areas of Dovray silty clay, which makes up not more than 11 percent of this mapping unit. This soil is in shallow depressions and swales. A few small wet areas are indicated by a spot symbol on the soil map.

Runoff is very slow on both soils. In a few areas water ponds on these soils in spring during periods when rainfall is heavy and snow melts rapidly. The Ryan soil has a claypan that is exposed by plowing. Soil blowing is a moderate hazard.

Nearly all areas of this complex are used for crops, but a few areas are in grass that is cut for hay or used for pasture. This complex is fairly well suited to farming if tilth can be maintained. It is not generally suited to trees. These soils are difficult to till, and good tilth is difficult to maintain. Improving and maintaining tilth, fertility, and permeability and removing excess water are the main concerns of management. Capability unit IIIs–4P; Fargo part in windbreak suitability group 1, Ryan part in windbreak suitability group 9.

Galchutt Series

The Galchutt series consists of deep, somewhat poorly drained, nearly level soils. These soils are in broad areas on the glacial lake plain. They formed in moderately fine textured glacial melt-water deposits and the underlying fine textured glacial lacustrine deposits.

In a representative profile the surface layer is black silty clay loam about 16 inches thick. The subsurface layer, about 8 inches thick, is very dark grayish brown silt loam mottled with dark yellowish brown. The subsoil is dark gray clay about 12 inches thick. The underlying material is olive gray clay mottled with brown.

Permeability is moderate in the upper part and slow in the subsoil and underlying material. The available water capacity is high. The organic-matter content and fertility are high. These soils have a seasonal water table 1 to 3 feet below the surface.

Galchutt soils are well suited to farming and to trees. Nearly all areas of these soils are used for crops. The limitations for many nonfarm uses are moderate and severe.

Representative profile of Galchutt silty clay loam, in an area of Galchutt-Fargo complex, in a cultivated field, 2,590 feet north and 2,425 feet east of the southwest corner of sec. 26, T. 146 N., R. 51 W.

Ap—0 to 7 inches, black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) when dry; weak medium granular structure; hard, friable, sticky and plastic; many roots and pores; neutral; abrupt smooth boundary.

A12—7 to 16 inches, black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) when dry; few fine distinct dark yellowish brown mottles in lower part; weak medium blocky structure parting to weak medium granular; hard, friable, sticky and plastic; many roots and pores; slightly acid; clear smooth boundary.

A2—16 to 24 inches, very dark grayish brown (2.5Y 3/2) silt loam, grayish brown (2.5Y 5/2) when dry; common fine distinct dark yellowish brown mottles; weak medium prismatic structure parting to weak medium platy; slightly hard, very friable, sticky and plastic; many roots and pores; many unstained sand grains on ped faces; neutral; clear wavy boundary.

IIB2t—24 to 30 inches, dark gray (5Y 4/1) clay, gray (5Y 6/1) when dry; moderate medium prismatic structure parting to strong medium blocky; very hard, very firm, very sticky and very plastic; many roots and common pores; tongues of A horizon extend into this horizon; clay films on prisms and blocks; neutral; gradual wavy boundary.

IIB3—30 to 36 inches, dark gray (5Y 4/1) clay, light gray (5Y 6/1) when dry; weak medium prismatic structure parting to weak fine blocky; very hard, firm, very sticky and very plastic; few roots and common pores; strongly effervescent; mildly alkaline; gradual wavy boundary.

IIC—36 to 60 inches, olive gray (5Y 5/2) clay, light olive gray (5Y 6/2) when dry; few fine distinct brown mottles; weak fine blocky structure; very hard, very firm, very sticky and very plastic; strongly effervescent; mildly alkaline.

The A1 horizon ranges from 10 to 20 inches in thickness. It is black or very dark gray silt loam or silty clay loam. The A2 horizon ranges from 6 to 14 inches in thickness. It is very dark gray to dark grayish brown silt loam or loam. Depth to the IIB horizon ranges from 16 to 36 inches. This horizon is dark gray to olive and has few to many, distinct or prominent mottles. In some places it has a few soft lime concretions.

Galchutt soils are near the Bearden, Fargo, and Wheatville soils. Unlike Bearden and Wheatville soils, they lack a layer where lime has accumulated within 16 inches of the surface. They have a platy A2 horizon, which is lacking in Fargo soils.

Ga—Galchutt-Fargo complex. The soils of this complex are nearly level and are in broad, flat areas on the glacial lake plain. This complex is at least 60 percent Galchutt silty clay loam or silt loam and is about 33 percent Fargo silty clay loam or silty clay. Slopes are 0 to 1 percent.

The Galchutt soils have a thicker deposit of silty material over clay and are better drained than Fargo soils. The Fargo soil has a profile similar to the one described as representative of the series, but the surface layer is silty clay loam instead of silty clay in places.

Included with this complex in mapping are some areas of a Bearden soil that has a clay substratum at a depth of 2 to 5 feet and which makes up not more than 7 percent of this mapping unit.

Runoff is very slow. In some places water ponds on the soils of this complex for short periods in spring during periods when snow melts rapidly and rainfall is heavy.

Nearly all areas of this complex are used for crops. The soils are well suited to farming and to trees. The Galchutt soils are more easily tilled than the Fargo soils. Removing excess water and maintaining and improving tilth and permeability are the main concerns of management. Capability unit IIw–6; windbreak suitability group 1.

Gardena Series

The Gardena series consists of deep, nearly level to sloping, moderately well drained soils. These soils are on beaches, on breaks along drainageways and streams, and in broad areas on the delta and between the beaches. They formed in medium textured glacial melt-water deposits.

In a representative profile the surface layer is black silt loam about 15 inches thick. The subsoil is silt loam about 17 inches thick. The upper part is very dark gray, and the lower part is very dark grayish brown. The underlying material is light olive brown silt loam mottled with dark brown.

Permeability is moderate, and the available water capacity is high. The organic-matter content and fertility are high. These soils have a deep water table.

In nearly all areas Gardena soils are well suited to farming and to trees. Nearly all areas of these soils are used for crops, but a few areas are in grass. The limitations for many nonfarm uses are slight and moderate.

Representative profile of Gardena silt loam, in a cultivated field, 1,260 feet north and 145 feet west of the southeast corner of sec. 5, T. 148 N., R. 53 W.

Ap—0 to 8 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) when dry; weak medium granular structure; slightly hard, friable, slightly sticky and slightly plastic; many roots and common pores; neutral; abrupt smooth boundary.

A12—8 to 15 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) when dry; weak coarse blocky structure parting to weak medium granular; slightly hard, friable, slightly sticky and slightly plastic; common roots and pores; neutral; gradual wavy boundary.

B21—15 to 20 inches, very dark gray (10YR 3/1) silt loam, gray (10YR 5/1) when dry; weak medium and coarse prismatic structure; slightly hard, friable, slightly sticky and slightly plastic; common roots and pores; neutral; gradual wavy boundary.

B22—20 to 32 inches, very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) when dry; weak medium and coarse prismatic structure parting to weak coarse blocky; slightly hard, friable, slightly sticky and slightly plastic; few roots and common pores; neutral; gradual wavy boundary.

C—32 to 60 inches, light olive brown (2.5Y 5/4) silt loam, pale yellow (2.5Y 7/4) when dry; few fine distinct dark brown mottles; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; slightly effervescent; mildly alkaline.

The solum ranges from 19 to 38 inches in thickness. The A horizon ranges from 10 to 20 inches in thickness. It is black or very dark gray silt loam, loam, or very fine sandy loam. The B horizon ranges from 9 to 18 inches in thickness. It is very dark gray to dark grayish brown very fine sandy loam to silt loam. In some places a layer that has an accumulation of lime is just below the B horizon. The C horizon is dark grayish brown to light yellowish brown. It commonly is very fine sandy loam or silt loam, but in some places below a depth of 40 inches, it is fine sand, clay loam, silty clay loam, silty clay, or clay. This horizon is mildly alkaline or moderately alkaline. It has few to common, faint to distinct mottles.

Gardena soils are near the Eckman, Glyndon, and Zell soils. They have a thicker A horizon than Eckman soils. Gardena soils are better drained than Glyndon soils, and they lack a layer where lime has accumulated within 16 inches of the surface. They have a thicker solum than Zell soils.

Gd—Gardena silt loam. This nearly level soil is on narrow to broad beaches and in broad areas on the delta and between the beaches. It has the profile described as representative of the series. The surface layer is silt loam in most places, but it is loam or very fine sandy loam in a few places. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Glyndon silt loam, which makes up not more than 10 percent of this mapping unit, and Tiffany loam, which makes up not more than 7 percent. The Glyndon soil is on slightly convex lower side slopes, and the Tiffany soil is in shallow depressions and swales. Small wet areas and a few small areas that are steep and have short slopes are indicated by spot symbols on the soil map.

Runoff is slow. Soil blowing is a moderate hazard.

All areas of this soil are used for crops. This soil is well suited to farming and to trees. Controlling soil blowing and conserving moisture are the main concerns of management. Capability unit IIe–5; windbreak suitability group 1.

GeB—Gardena-Eckman silt loams, 3 to 6 percent slopes. The soils of this complex are gently sloping and are on beaches and breaks to drainageways and streams on the delta and between the beaches. Slopes are short. The Gardena soil is on plane and concave side slopes, and the Eckman soil is on convex side slopes. This complex is at least 60 percent Gardena silt loam and is about 30 percent Eckman silt loam.

In a few places these soils have a surface layer of loam or very fine sandy loam instead of silt loam. The

Eckman soil has the profile described as representative of the series.

Included with this complex in mapping are some areas of Zell silt loam, which makes up not more than 10 percent of this mapping unit. This soil is on the crests of beaches and breaks. A few small areas that are steep and have short slopes are indicated by a spot symbol on the soil map.

Runoff is medium. The hazards of soil blowing and water erosion are moderate.

Most areas of this complex are used for crops, but some areas are in grass that is cut for hay or used for pasture. The soils are well suited to farming and to trees. Controlling water erosion and soil blowing and conserving moisture are the main concerns of management. Capability unit IIe–5; Gardena part in windbreak suitability group 1, Eckman part in windbreak suitability group 3.

GfC—Gardena-Zell silt loams, 6 to 9 percent slopes. The soils of this complex are sloping and are on beaches and breaks to drainageways and streams on the delta and between the beaches. Slopes are short. The Gardena soil is on plane and concave side slopes, and the Zell soil is on convex side slopes. This complex is at least 50 percent Gardena silt loam and at least 35 percent Zell silt loam. In a few places these soils have a surface layer of loam instead of silt loam.

Included with this complex in mapping are some areas of Eckman silt loam, which makes up not more than 10 percent of this mapping unit, and Zell soils that have a lighter colored surface layer than is representative of the series and which make up not more than 5 percent. A few small areas that are steep and have short slopes are indicated by a spot symbol on the soil map.

Runoff is medium on the Gardena soil and rapid on the Zell soil. Water erosion is a severe hazard, and soil blowing is a moderate hazard.

Most areas of this complex are used for crops, but a few areas are in grass that is used for wildlife food and cover, cut for hay, or used for pasture. This complex is fairly well suited to farming and well suited or fairly well suited to trees. Controlling water erosion and soil blowing and conserving moisture are the main concerns of management. Capability unit IIIe–5; Gardena part in windbreak suitability group 3, Zell part in windbreak suitability group 8.

Gilby Series

The Gilby series consists of deep, somewhat poorly drained, nearly level soils. These soils are in broad areas between the beaches. They formed in medium textured glacial melt-water deposits and the underlying medium textured and moderately fine textured water-worked glacial till.

In a representative profile the surface layer is black loam about 8 inches thick. The underlying material, to a depth of 21 inches, is loam that has an accumulation of lime. The upper part is gray, and the lower part is grayish brown and mottled with black. Below this is grayish brown loam, about 5 inches thick, mottled with dark brown. The lower part of the underlying material is clay loam mottled with gray and brown. The upper part is light olive gray, and the lower part is pale olive.

Permeability is moderate in the surface layer and the upper part of the underlying material and moderately slow in the lower part of the underlying material. The available water capacity is high, except in saline areas. The organic-matter content is high, and fertility is medium. These soils have a seasonal high water table 1 to 3 feet below the surface.

In most areas Gilby soils are well suited to farming and to trees. Most areas of these soils are used for crops, but some are in grass. The limitations for many nonfarm uses are moderate and severe.

Representative profile of Gilby loam, in an area of Gilby-Tonka complex, in a cultivated field, 258 feet south and 2,498 feet east of the northwest corner of sec. 10, T. 147 N., R. 51 W.

Ap—0 to 8 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) when dry; weak coarse subangular blocky structure parting to weak medium granular; slightly hard, friable, sticky and plastic; few roots and pores; strongly effervescent; neutral; abrupt smooth boundary.

C1ca—8 to 14 inches, gray (2.5Y 6/1) loam, light gray (2.5Y 7/1) when dry; weak coarse prismatic structure parting to weak medium blocky; slightly hard, friable, sticky and plastic; few roots and common pores; violently effervescent; mildly alkaline; clear smooth boundary.

C2ca—14 to 21 inches, grayish brown (2.5Y 5/2) loam, light brownish gray (2.5Y 6/2) when dry; few fine distinct black mottles; weak coarse prismatic structure parting to weak coarse blocky; slightly hard, very friable, slightly sticky and slightly plastic; few roots and common pores; violently effervescent; mildly alkaline; gradual smooth boundary.

C3—21 to 26 inches, grayish brown (2.5Y 5/2) loam, light gray (2.5Y 7/2) when dry; few fine distinct dark brown mottles; weak coarse prismatic structure parting to weak coarse blocky; slightly hard, very friable, slightly sticky and slightly plastic; few roots and common pores; strongly effervescent; mildly alkaline; gradual wavy boundary.

IIC4g—26 to 38 inches, light olive gray (5Y 6/2) clay loam, light gray (5Y 7/2) when dry; common medium faint gray (5Y 5/1) mottles and many medium prominent brown (7.5YR 4/4) mottles; moderate medium prismatic structure parting to moderate medium blocky; hard, firm, very sticky and very plastic; few medium nests of gypsum crystals; strongly effervescent; mildly alkaline; gradual wavy boundary.

IIC5—38 to 60 inches, pale olive (5Y 6/3) clay loam, pale yellow (5Y 7/3) when dry; common medium distinct gray (5Y 5/1) mottles and many coarse prominent brown (7.5YR 4/4) mottles; massive; hard, firm, very sticky and very plastic; common medium nests of gypsum crystals; strongly effervescent; mildly alkaline.

The A horizon ranges from 7 to 15 inches in thickness and is black or very dark gray. It is dominantly loam, but it is silt loam in places. This horizon ranges from neutral to moderately alkaline. The C horizon is mildly alkaline or moderately alkaline, and in some areas, it contains moderate amounts of soluble salts. The Cca horizon ranges from 10 to 20 inches in thickness. It is dark gray to grayish brown loam, silt loam, or very fine sandy loam. In most places a thin layer of sandy, gravelly, or stony material is at the contact with the firm water-worked glacial till. The depth to the IIC horizon ranges from 20 to 40 inches. This horizon is firm loam or clay loam water-worked glacial till.

Gilby soils are near the Glyndon, Lankin, and Tonka soils. Unlike Glyndon soils, Gilby soils have glacial till within 40 inches of the surface. They are more poorly

drained than Lankin soils, and they lack a B horizon. They lack a platy A2 horizon, which Tonka soils have.

Gg—Gilby loam. This nearly level soil is in broad areas between the beaches. The surface layer is loam in most places, but it is silt loam in a few places. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Lankin loam, which makes up not more than 15 percent of this mapping unit, and Tonka silt loam, which makes up not more than 10 percent. The Lankin soil is on plane slopes, and the Tonka soil is in shallow depressions. Small wet areas and a few small saline areas are indicated by spot symbols on the soil map.

Soil blowing is a moderate hazard. Runoff is very slow. In a few places water ponds for short periods in spring during periods when rainfall is heavy and snow melts rapidly. In many areas a few small to large stones interfere with tillage.

Nearly all areas of this soil are used for crops, but a few areas are in grass that is cut for hay or used for pasture. This soil is well suited to farming and to trees. Controlling soil blowing and removing excess water and stones are the main concerns of management. Capability unit IIe–4L; windbreak suitability group 1.

Gh—Gilby-Tonka complex. The soils of this complex are nearly level and are in broad areas between the beaches. The Gilby soil is on plane and slightly convex slopes, and the Tonka soil is in small, shallow depressions and swales. This complex is at least 55 percent Gilby loam and is about 35 percent Tonka silt loam. Slopes are 0 to 1 percent.

In a few areas the Gilby soil has a surface layer of silt loam instead of loam. It has the profile described as representative of the series.

Included with this complex in mapping are some areas of Vallers clay loam, which makes up not more than 10 percent of this mapping unit. This soil is on the rims of depressions and swales. A few small saline areas are indicated by a spot symbol on the soil map.

Soil blowing is a moderate hazard on the Gilby soil and a slight hazard on the Tonka soil. Runoff is very slow on the Gilby soil and ponded on the Tonka soil. Water ponds on the Tonka soil in spring and during periods of heavy rainfall. In many areas a few small to large stones interfere with tillage.

Most areas of this complex are used for crops, but some areas are in grass that is used for wildlife food and cover, cut for hay, or used for pasture. This complex is well suited to farming and, if excess water is removed, to trees. Controlling soil blowing and removing excess water and stones are the main concerns of management. Capability unit IIew–4L; Gilby part in windbreak suitability group 1, Tonka part in windbreak suitability group 2.

Gk—Gilby-Tonka complex, saline. The soils of this complex are nearly level and are in broad areas between the beaches. The Gilby soil is on plane and convex slopes, and the Tonka soil is in small, shallow depressions. This complex is at least 45 percent Gilby loam, saline, and is about 35 percent Tonka silt loam. Slopes are 0 to 1 percent.

The Gilby soil has a profile similar to the one described as representative of the series, but is saline. Included with this complex in mapping are some areas of Gilby loam, which is not saline and which makes up not more than 20 percent of this mapping unit.

The available water capacity is moderate in the Gilby soil and high in the Tonka soil. The Gilby soil contains enough soluble salts to affect plant growth. Runoff is very slow on the Gilby soil and ponded on the Tonka soil. Water ponds on the Tonka soil in spring and during periods of heavy rainfall. Soil blowing is a moderate hazard on the Gilby soil and a slight hazard on the Tonka soil. In many areas a few small to large stones interfere with tillage.

Most areas of this complex are used for crops, but some areas are in grass that is used for wildlife food and cover, cut for hay, or used for pasture. This complex is fairly well suited to farming, but it is not suited to trees in most places. Controlling salinity and soil blowing, selecting salt-tolerant crops, and removing stones and excess water are the main concerns of management. Capability unit IIIs–4L; Gilby part in windbreak suitability group 10, Tonka part in windbreak suitability group 2.

Glyndon Series

The Glyndon series consists of deep, somewhat poorly drained, nearly level soils. These soils are in broad areas on the delta, between the beaches, and on the glacial lake plain. They formed in medium textured glacial melt-water deposits.

In a representative profile the surface layer is black silt loam about 8 inches thick. The underlying material, to a depth of 24 inches, is silt loam that has an accumulation of lime. The upper part is dark gray, and the lower part is light brownish gray. Below this is very fine sandy loam that is grayish brown and mottled with dark brown and light olive brown and mottled with dark brown and gray.

Permeability is moderate. The available water capacity is high, except in saline areas. The organic-matter content is high, and fertility is medium. These soils have a seasonal high water table 3 to 5 feet below the surface.

Nearly all areas of Glyndon soils are well suited to farming and most areas are suited to trees. Nearly all areas of these soils are used for crops, but a few areas are in grass. The limitations for nonfarm uses range from slight to severe.

Representative profile of Glyndon silt loam, in a cultivated field, 135 feet east and 595 feet south of the northwest corner of sec. 13, T. 147 N., R. 52 W.

Ap—0 to 8 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) when dry; weak fine granular structure; slightly hard, very friable, slightly sticky and slightly plastic; many roots and pores; strongly effervescent; mildly alkaline; abrupt smooth boundary.

C1ca—8 to 13 inches, dark gray (10YR 4/1) silt loam, gray (10YR 6/1) when dry; weak coarse prismatic structure parting to weak coarse blocky; soft, very friable, slightly sticky and slightly plastic; many roots and common pores; violently effervescent; mildly alkaline; clear wavy boundary.

C2ca—13 to 24 inches, light brownish gray (2.5Y 6/2) silt loam, light gray (2.5Y 7/2) when dry; weak coarse prismatic structure parting to weak coarse blocky; soft, very friable, slightly sticky and slightly plastic; common roots and pores; violently effervescent; mildly alkaline; gradual wavy boundary.

C3—24 to 40 inches, grayish brown (2.5Y 5/2) very fine sandy loam, light gray (2.5Y 7/2) when dry; few fine distinct dark brown mottles; weak coarse prismatic structure; soft, very friable, slightly sticky and slightly plastic; few foots and pores; strongly effervescent; mildly alkaline; gradual wavy boundary.

C4—40 to 60 inches, light olive brown (2.5Y 5/4) very fine sandy loam, light yellowish brown (2.5Y 6/4) when dry; many coarse prominent dark brown (7.5YR 4/4) mottles and many medium distinct gray (5Y 6/1) mottles; massive; soft, loose, nonsticky and nonplastic; slightly effervescent; mildly alkaline.

Gypsum crystals and other salts are in some places. The soil is mildly alkaline or moderately alkaline. The A horizon ranges from 7 to 12 inches in thickness and is black or very dark gray. It is silt loam in most places, but it is loam or very fine sandy loam in some places. The C horizon is very fine sandy loam in most places, but it is loam or silt loam in some places. The Cca horizon is silt loam in most places, but it is loam or very fine sandy loam in some places.

Glyndon soils formed in material similar to that in which the Borup, Eckman, and Gardena soils formed. They are better drained than Borup soils. They are more poorly drained than Eckman and Gardena soils and, unlike those soils, lack a B horizon.

Gm—Glyndon silt loam. This nearly level soil is in broad areas on the delta, between the beaches, and on the glacial lake plain. It has the profile described as representative of the series. The surface layer is silt loam in most places, but it is loam or very fine sandy loam in a few places. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Gardena silt loam, which makes up not more than 10 percent of this mapping unit, and Tiffany loam, Perella silt loam, or both, which make up not more than 15 percent. The Gardena soil is on plane slopes, and the Tiffany and Perella soils are in shallow depressions and swales. Also included are some areas of a soil that has a clay substratum at a depth of 40 to 60 inches. Small wet areas, a few small saline areas, and a few small areas that are steep and have short slopes are indicated by spot symbols on the soil map.

Soil blowing is a moderate hazard. Runoff is slow.

Nearly all areas of this soil are used for crops. This soil is well suited to farming and to trees. Controlling soil blowing and improving fertility are the main concerns of management. Capability unit IIe–4L; windbreak suitability group 1.

Gn—Glyndon silt loam, saline. This nearly level soil is in small to large areas on the delta, between the beaches, and on the glacial lake plain. It has a profile similar to the one described as representative of the series, but is saline. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Glyndon silt loam, which is not saline and which makes up not more than 20 percent of this mapping unit, and Borup silt loam, Perella silt loam, or both, which make up not more than 10 percent. The Borup or Perella soils are in shallow swales or depressions. A few small wet areas are indicated by a spot symbol on the soil map.

The available water capacity is moderate. This soil contains enough soluble salts to affect plant growth. Soil blowing is a moderate hazard.

Most areas of this soil are used for crops, but some areas are in grass that is used for wildlife food and cover, cut for hay, or used for pasture. This soil is fairly well suited to farming, but it is not suited to trees. Controlling salinity and soil blowing, selecting salt-tolerant crops, and improving fertility are the main concerns of management. Capability unit IIIs–4L; windbreak suitability group 10.

Go—Glyndon-Perella silt loams. The soils of this complex are nearly level and are in broad areas on the delta and glacial lake plain. The Glyndon soil is on plane and slightly convex slopes, and the Perella soil is in shallow depressions. This complex is about 60 percent Glyndon silt loam and about 30 percent Perella silt loam. Slopes are 0 to 1 percent.

The Perella soil has a profile similar to the one described as representative of the series, but it is silt loam throughout the profile.

Included with this complex in mapping are some areas of Bearden silt loam, which makes up not more than 10 percent of this mapping unit. This soil is on plane and slightly convex slopes. A few small saline areas are indicated by a spot symbol on the soil map.

The hazard of soil blowing is moderate on the Glyndon soil and slight on the Perella soil. Runoff is slow on the Glyndon soil and very slow on the Perella soil. In many areas of the Perella soil, water ponds for short periods in spring when rainfall is heavy and snow melts rapidly.

All areas of this complex are used for crops. This complex is well suited to farming and, if excess water is removed, to trees. Controlling soil blowing and removing excess water are the main concerns of management. Capability unit IIew–4L; Glyndon part in windbreak suitability group 1, Perella part in windbreak suitability group 2.

Gr—Glyndon-Tiffany loams. The soils of this complex are nearly level and are in broad areas on the delta. The Glyndon soil is on plane and slightly convex slopes, and the Tiffany soil is in small, shallow depressions. This complex is about 60 percent Glyndon loam and about 30 percent Tiffany loam. Slopes are 0 to 1 percent. The Glyndon soil has a profile similar to the one described as representative of the series, but it is loam throughout the profile.

Included with this complex in mapping are some areas of Gardena silt loam, which makes up not more than 10 percent of this mapping unit. This soil is on plane and slightly concave slopes. Also included are some areas of a soil that has a clay substratum at a depth of 40 to 60 inches.

Soil blowing is a moderate hazard. Runoff is slow on the Glyndon soil and very slow on the Tiffany soil. In most areas of the Tiffany soil, water ponds for short periods in spring when rainfall is heavy and snow melts rapidly.

Nearly all areas of this complex are used for crops, but a few areas are in grass that is cut for hay or used for pasture. This complex is well suited to farming and to trees if excess water is removed. Controlling soil blowing and removing excess water are the main concerns of management. Capability unit IIew–4L; Glyndon part in windbreak suitability group 1, Tiffany part in windbreak suitability group 2.

Grano Series

The Grano series consists of deep, nearly level, very

poorly drained soils. These soils are in closed depressions between the beaches and on the glacial lake plain. They formed in fine textured glacial lacustrine deposits.

In a representative profile the surface layer is black silty clay about 16 inches thick. The underlying material, to a depth of 44 inches, is silty clay that has an accumulation of lime. The upper part is dark gray, and the lower part is gray and mottled with yellowish brown. Below this is olive gray silty clay mottled with yellowish brown.

Permeability is slow, and the available water capacity is high. The organic-matter content is high, and fertility is medium. This soil has a high water table at a depth of 0 to 3 feet.

Grano soils are fairly well suited to farming and suited to trees if excess water is removed. Nearly all areas of these soils are used for hay, pasture, and wildlife habitat, but a few areas are used for crops. The limitations for most nonfarm uses are severe.

Representative profile of Grano silty clay, under sedges and rushes, 1,722 feet west and 316 feet north of the southeast corner of sec. 12, T. 144 N., R. 52 W.

A1—0 to 16 inches, black (2.5Y 2/0) silty clay, dark gray (2.5Y 4/0) when dry; weak medium granular structure; very hard, firm, very sticky and very plastic; many roots and pores; slightly effervescent; mildly alkaline; clear smooth boundary.

C1gca—16 to 26 inches, dark gray (5Y 4/1) silty clay, light gray (5Y 6/1) when dry; weak medium prismatic structure parting to moderate fine blocky; very hard, firm, very sticky and very plastic; common roots and pores; violently effervescent; mildly alkaline; gradual wavy boundary.

C2gca—26 to 44 inches, gray (5Y 5/1) silty clay, light gray (5Y 6/1) when dry; common medium distinct yellowish brown (10YR 5/6) mottles; moderate fine blocky structure; very hard, firm, very sticky and very plastic; few roots and common pores; violently effervescent; mildly alkaline; gradual wavy boundary.

C3g—44 to 60 inches, olive gray (5Y 5/2) silty clay, light gray (5Y 7/2) when dry; common coarse prominent yellowish brown (10YR 5/6) mottles; weak fine blocky structure; very hard, firm, very sticky and very plastic; strongly effervescent; mildly alkaline.

These soils are mildly alkaline or moderately alkaline. The A horizon ranges from 16 to 24 inches in thickness and is black or very dark gray. It is silty clay in most places, but it is silty clay loam or clay in a few places. Tongues of material from the A horizon extend to a depth of 30 inches in some places. The Cgca horizon ranges from 12 to 30 inches in thickness. It is very dark gray to gray silty clay or clay. The Cg horizon has few to many, distinct or prominent mottles. Below a depth of 40 inches, this horizon is silty clay or clay in many places, but it is silty clay loam or clay loam in some places.

Grano soils formed in material similar to that in which the Dovray, Fargo, and Hegne soils formed. Unlike Dovray soils, they are calcareous at a depth of 10 inches or less and have a layer where lime has accumulated within 24 inches of the surface. They are more poorly drained than Fargo and Hegne soils.

Gs—Grano silty clay. This nearly level soil is in closed depressions between the beaches and on the glacial lake plain. It has the profile described as representative of the series. The surface layer is silty clay in most places, but it is silty clay loam or clay in a few places. Slopes are 0 to 1 percent.

Included with this soil in mapping are a few small areas where the soil is saline. A few other small areas are indicated by a spot symbol on the soil map.

Runoff is ponded. Water ponds on this soil in spring and during periods of heavy rainfall. A high water table is at or near the surface in spring and during periods of heavy rainfall.

Nearly all areas of this soil are used for hay, pasture, and wildlife habitat, but a few areas where excess water has been removed are used for crops. This soil is fairly well suited to farming and to trees if excess water is removed. Removing excess water, maintaining tilth and permeability, and maintaining high-quality vegetation for hay and pasture are the main concerns of management. Capability unit IIIw–4; windbreak suitability group 2.

Gravel Pits

Gravel pits are excavated areas from which the soil material has been removed to mine the underlying sand and gravel. They are irregularly shaped pits and dumps that are mostly barren. Sand, stones, and gravel are exposed at the surface. This land type is in areas of Arvilla, Divide, Renshaw, and Sioux soils.

This land type is not suited to grass or other uses unless it is leveled and soil material is placed on it. Not in a capability unit or windbreak suitability group.

Great Bend Series

The Great Bend series consists of deep, nearly level to strongly sloping, well drained soils. These soils are on beaches, ridges, and breaks to drainageways and streams on the delta, between the beaches, and on the glacial lake plain. They formed in medium textured and moderately fine textured glacial lacustrine deposits.

In a representative profile the surface layer is black silty clay loam about 8 inches thick. The subsoil is silty clay loam about 10 inches thick. The upper part of the subsoil is dark grayish brown, and the lower part is grayish brown. The underlying material is light olive brown silty clay loam mottled with yellowish red in the lower part.

Permeability is moderate, and the available water capacity is high. The organic-matter content is high, and fertility is medium. These soils have a deep water table.

Great Bend soils are fairly well suited to farming in many areas and well suited to trees in most areas. Most areas of this soil are used for crops, but a few areas are in grass and native woodland. The limitations for nonfarm uses range from slight to severe.

Representative profile of Great Bend silty clay loam, 9 to 15 percent slopes, in a cultivated field, 1,900 feet west and 970 feet south of the northeast corner of sec. 36, T. 147 N., R. 53 W.

Ap—0 to 6 inches, black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) when dry; weak fine granular structure; slightly hard, friable, sticky and plastic; many roots and common pores; neutral; abrupt smooth boundary.

A12—6 to 8 inches, black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) when dry; weak coarse subangular blocky structure parting to weak fine granular; slightly hard, friable, sticky and plastic; many roots and common pores; neutral; clear smooth boundary.

B2—8 to 13 inches, dark grayish brown (10YR 4/2) silty clay loam, brown (10YR 5/3) when dry; moderate medium prismatic structure parting to moderate fine blocky; hard, friable, sticky and plastic; common roots and pores; neutral; clear smooth boundary.

B3—13 to 18 inches, grayish brown (2.5Y 5/2) silty clay loam, light gray (2.5Y 7/2) when dry; moderate medium blocky structure; hard, friable, sticky and plastic; common roots and pores; strongly effervescent; neutral; clear wavy boundary.

C1—18 to 36 inches, light olive brown (2.5Y 5/4) silty clay loam, pale yellow (2.5Y 7/4) when dry; weak moderate prismatic structure; slightly hard, friable, sticky and plastic; few roots and common pores; strongly effervescent; mildly alkaline; gradual wavy boundary.

C2—36 to 60 inches, light olive brown (2.5Y 5/4) silty clay loam, pale yellow (2.5Y 7/4) when dry; common fine distinct yellowish red mottles; massive; slightly hard, friable, sticky and plastic; slightly effervescent; mildly alkaline.

The solum ranges from 12 to 26 inches in thickness. The A horizon ranges from 5 to 10 inches in thickness and is black or very dark gray. It is silty clay loam in most places, but it is silt loam in a few places. The B horizon ranges from 6 to 12 inches in thickness and is very dark grayish brown to brown. It is silty clay loam in most places, but it is silt loam in a few places. The C horizon ranges from dark grayish brown to light yellowish brown. It is silty clay loam in many places, but below a depth of 40 inches, it is very fine sandy loam, silt loam, clay loam, silty clay, or clay in a few places.

Great Bend soils are near the Bearden, Overly, and Perella soils. They are better drained than Bearden soils, but they lack a layer where lime has accumulated within 16 inches of the surface. They have a thinner solum than Overly soils. They are better drained than Perella soils, but they lack mottling so near the surface.

GwA—Great Bend silty clay loam, 1 to 3 percent slopes. This nearly level soil is on low ridges on the glacial lake plain. The surface layer is silty clay loam in most places, but it is silt loam in a few places.

Included with this soil in mapping are some areas of Overly silty clay loam, which makes up not more than 15 percent of this mapping unit, and Bearden silty clay loam, which makes up not more than 10 percent. The Overly soil is on plane and slightly concave side slopes, and the Bearden soil is on slightly convex side slopes.

Runoff is medium. The hazards of soil blowing and water erosion are slight.

All areas of this soil are used for crops. This soil is well suited to farming and to trees. Conserving moisture, improving fertility, and maintaining tilth are the main concerns of management. Capability unit IIc–6; windbreak suitability group 3.

GwC—Great Bend silty clay loam, 6 to 9 percent slopes. This sloping soil is on beaches and breaks to drainageways and streams on the delta, between the beaches, and on the glacial lake plain. The surface layer is silty clay loam in most places, but it is silt loam in a few places.

Included with this soil in mapping are small areas of a soil that is calcareous at the surface. A few small areas that are steep and have short slopes are indicated by a spot symbol on the soil map.

Runoff is medium. Water erosion is a severe hazard.

Most areas of this soil are used for crops, but a few areas are in grass and native woodland that is used for pasture and wildlife habitat. This soil is fairly well suited to farming and well suited to trees. Controlling water erosion, improving fertility, maintaining tilth, and conserving moisture are the main concerns of management. Capability unit IIIe–6; windbreak suitability group 3.

GwD—Great Bend silty clay loam, 9 to 15 percent slopes. This strongly sloping soil is on breaks to drainageways and streams on the delta and glacial lake plain. It has the profile described as representative of the series. The surface layer is silty clay loam in most places, but it is silt loam in a few places.

Included with this soil in mapping are areas of a soil that is calcareous at the surface. A few small areas that are steep and have short slopes are indicated by a spot symbol on the soil map.

Runoff is rapid. Water erosion is a very severe hazard.

Some areas of this soil are used for crops, and some areas are in grass and native woodland that is used for pasture or wildlife habitat. This soil is poorly suited to farming but fairly well suited to trees. Controlling water erosion, improving fertility, and maintaining organic-matter content are the main concerns of management. Capability unit IVe–6; windbreak suitability group 3.

Hamar Series

The Hamar series consists of deep, poorly drained, nearly level soils. These soils are in shallow depressions and swales on the delta and between the beaches. They formed in coarse textured glacial melt-water deposits.

In a representative profile the surface layer, about 12 inches thick, is black loamy fine sand mottled with very dark grayish brown in the lower part. The upper part of the underlying material is dark grayish brown loamy fine sand mottled with very dark gray and dark yellowish brown. The middle part is grayish brown loamy fine sand mottled with very dark gray and dark grayish brown. The lower part is olive gray fine sand mottled with dark yellowish brown.

Permeability is rapid, and the available water capacity is low. The organic-matter content is high, and fertility is medium. These soils have a seasonal water table 1 to 3 feet below the surface.

Hamar soils are poorly suited to farming but are well suited to trees if excess water is removed. Most areas of this soil are used for crops, but some areas are in grass. The limitations for most nonfarm uses are severe.

Representative profile of Hamar loamy fine sand, in a cultivated field, 135 feet south and 1,251 feet west of the northeast corner of sec. 8, T. 145 N., R. 53 W.

Ap—0 to 8 inches, black (10YR 2/1) loamy fine sand, very dark gray (10YR 3/1) when dry; weak medium granular structure; soft, very friable, slightly sticky and slightly plastic; common roots and pores; slightly acid; abrupt smooth boundary.

A12—8 to 12 inches, black (10YR 2/1) loamy fine sand, dark gray (10YR 4/1) when dry; common medium faint very dark grayish brown (10YR 3/2) mottles; weak coarse prismatic structure parting to weak coarse blocky; soft, very friable, slightly sticky and slightly plastic; common roots and many pores; slightly acid; abrupt smooth boundary.

C1g—12 to 2 inches, dark grayish brown (10YR 4/2) loamy fine sand, grayish brown (10YR 5/2) when dry; common fine distinct very dark gray mottles and many coarse distinct dark yellowish brown (10YR 4/4) mottles; weak coarse prismatic structure parting to weak coarse blocky; soft, loose, nonsticky and nonplastic; few roots and many pores; neutral; clear wavy boundary.

C2g—22 to 44 inches, grayish brown (2.5Y 5/2) loamy fine sand, light brownish gray (2.5Y 6/2) when dry; few fine distinct very dark gray mottles and common medium distinct dark yellowish brown (10YR 4/4) mottles; weak coarse prismatic structure; soft, loose, nonsticky and nonplastic; few roots and many pores; neutral; clear wavy boundary.

C3g—44 to 60 inches, olive gray (5Y 4/2) fine sand, light olive gray (5Y 6/2) when dry; many coarse prominent dark yellowish brown (10YR 4/4) mottles; single grained; loose, nonsticky and nonplastic; neutral.

These soils are commonly noncalcareous to a depth of 30 inches or more. The A horizon ranges from 12 to 24 inches in thickness and is black or very dark gray. It is loamy fine sand in most places, but it is sandy loam in a few places. This horizon is slightly acid to neutral. The C horizon is dark gray to grayish brown. It has few to many, faint to prominent mottles. It commonly is fine sand or loamy fine sand; but below a depth of about 40 inches, it ranges from fine sand to silt loam in some places. This horizon is neutral or mildly alkaline.

Hamar soils formed in material similar to that in which the Hecla, Maddock, and Ulen soils formed. They are more poorly drained and have mottles nearer the surface than Hecla and Maddock soils. They have a thicker A horizon than Maddock soils. They lack a calcareous A horizon, which Ulen soils have.

Ha—Hamar loamy fine sand. This nearly level soil is in shallow depressions and swales between the beaches and on the delta. It has the profile described as representative of the series. The surface layer is loamy fine sand in most places, but it is sandy loam in a few places. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Ulen fine sandy loam, which makes up not more than 15 percent of this mapping unit. This soil is on slightly convex slopes on the rims of depressions.

Runoff is very slow. In some areas water ponds in spring during periods when rainfall is heavy and snow melts rapidly. A seasonal water table is near the surface in spring and during periods of heavy rainfall. Soil blowing is a very severe hazard.

Most areas of this soil are used for crops, but some areas are in grass that is cut for hay or used for pasture. This soil is poorly suited to farming, but it is well suited to trees if excess water is removed. Controlling soil blowing, removing excess water, and improving fertility are the main concerns of management. Capability unit IVew–2; windbreak suitability group 2.

Hamerly Series

The Hamerly series consists of deep, somewhat poorly drained, nearly level soils. These soils are in broad areas between the beaches. They formed in moderately fine textured water-worked glacial till.

In a representative profile the surface layer is black clay loam about 7 inches thick. The underlying material, to a depth of 15 inches, is dark gray and very dark gray clay loam that has an accumulation of lime. Below this is dark grayish brown clay loam about 10 inches thick. The lower part of the underlying material is dark grayish brown and olive gray clay loam.

Permeability is moderate in the surface layer and moderately slow in the underlying material. The available water capacity is high, except in saline areas. The organic-matter content is high, and fertility is medium. These soils have a seasonal water table 3 to 5 feet below the surface.

In most areas Hamerly soils are well suited to farming and to trees. Most areas of these soils are used for crops, but a few areas are in grass. The limitations for most nonfarm uses are moderate and severe.

Representative profile of Hamerly clay loam, in an area of Hamerly-Tonka clay loams, in a cultivated field, 2,450 feet east and 160 feet north of the southwest corner of sec. 12, T. 147 N., R. 51 W.

Ap—0 to 7 inches, black (10YR 2/1) clay loam, very dark gray (10YR 3/1) when dry; weak medium and fine granular structure; hard, friable, sticky and plastic; many roots and pores; strongly effervescent; mildly alkaline; abrupt smooth boundary.

C1ca—7 to 15 inches, dark gray (2.5Y 4/1) and very dark gray (2.5Y 3/1) clay loam, light gray (2.5Y 6/1) and gray (2.5Y 5/1) when dry; few tongues of black (10YR 2/1) extending through this horizon; weak medium and fine granular structure; hard, friable, sticky and plastic; common roots and few pores; few small and medium nests of gypsum crystals; violently effervescent; mildly alkaline; clear irregular boundary.

C2—15 to 25 inches, dark grayish brown (2.5Y 4/3) clay loam, light brownish gray (2.5Y 6/3) when dry; few tongues of black (10YR 2/1) extending through this horizon; weak very coarse prismatic structure parting to weak medium granular; hard, friable, sticky and plastic; few roots and common pores; few medium nests of gypsum crystals; strongly effervescent; mildly alkaline; gradual wavy boundary.

C3—25 to 40 inches, dark grayish brown (2.5Y 4/3) clay loam, light gray (2.5Y 7/2) when dry; few tongues of very dark gray (10YR 3/1) extend into this horizon; weak medium platy structure parting to weak fine subangular blocky; hard, firm, sticky and plastic; few fine pores; common large nests of gypsum crystals; slightly effervescent; mildly alkaline; gradual wavy boundary.

C4—40 to 60 inches, dark grayish brown (2.5Y 4/3) clay loam, olive gray (5Y 5/2) on vertical faces, light gray (2.5Y 7/2) when dry; weak medium platy structure parting to moderate fine and very fine blocky; hard, firm, sticky and plastic; few fine and coarse pores; slightly effervescent; mildly alkaline.

These soils are 2 to 10 percent rock fragments. The A horizon ranges from 6 to 15 inches in thickness. It is very dark gray or black clay loam or silty clay loam. The lower part of the A horizon has an accumulation of lime in places. The C horizon contains few to common and small to medium nests of gypsum crystals. It is mildly alkaline or moderately alkaline and is slightly to violently effervescent. The Cca horizon ranges from 6 to 20 inches in thickness and is dark gray to grayish brown. It is mildly alkaline or moderately alkaline.

Hamerly soils are near the Divide, Gilby, and Tonka soils. They lack a IIC horizon of coarse sand and gravel, which Divide soils have. They contain more clay in the upper part of the profile than Gilby soils. Unlike Tonka soils, Hamerly soils have a layer where lime has accumulated within 16 inches of the surface.

Hb—Hamerly-Tonka clay loams. The soils of this complex are nearly level and are in broad areas between the beaches. The Hamerly soil is on plane and slightly convex slopes, and the Tonka soil is in small,

shallow depressions. This complex is about 60 percent Hamerly clay loam and about 30 percent Tonka clay loam. Slopes are 0 to 1 percent.

In a few areas these soils have a surface layer of loam instead of clay loam. The Hamerly soil has the profile described as representative of the series. The Tonka soil has a profile similar to the one described as representative of the series, but the surface layer is clay loam.

Included with this complex in mapping are some areas of Doran clay loam, which makes up about 10 percent of this mapping unit. This soil is on plane and slightly concave slopes. In some areas the included Doran soil is more poorly drained than is representative of the series. Also included in mapping are areas of Hamerly soil that contain less sand and more silt than is representative of the series. A few small saline areas are indicated by a spot symbol on the soil map.

The hazard of soil blowing is moderate on the Hamerly soil and slight on the Tonka soil. Runoff is slow on the Hamerly soil and ponded on the Tonka soil. Water ponds on the Tonka soil in spring and during periods of heavy rainfall. In most areas small to large stones interfere with tillage. Most of the stones are on the Hamerly soil and are concentrated in the upper part of the soil.

Most areas of this complex are used for crops, but a few areas are in grass that is cut for hay, used for pasture, or used for wildlife habitat. This complex is well suited to farming and to trees if excess water is removed. Removing excess water, maintaining tilth, controlling soil blowing, and removing stones are the main concerns of management. Capability unit IIew–4L; Hamerly part in windbreak suitability group 1, Tonka part in windbreak suitability group 2.

Hc—Hamerly-Tonka clay loams, saline. The soils of this complex are nearly level and are in broad areas between the beaches. The Hamerly soil is on plane and slightly convex slopes, and the Tonka soil is in small, shallow depressions. This complex is about 60 percent Hamerly clay loam, saline, and about 30 percent Tonka clay loam. Slopes are 0 to 1 percent.

The Hamerly soil has a profile similar to the one described as representative of the series, but is saline. The Tonka soil has a profile similar to the one described as representative of the series, but the surface layer is clay loam instead of silt loam.

Included with this complex in mapping are areas of Doran clay loam, which makes up about 10 percent of this mapping unit. This soil is on plane and slightly concave slopes, and in some areas it is more poorly drained than is representative of the series. Also included in mapping are areas of a Hamerly soil that is not saline and areas that contain less sand and more silt than is representative of the series.

The available water capacity is moderate in the Hamerly soil and high in the Tonka soil. The Hamerly soil contains enough soluble salts to affect plant growth, but the Tonka soil is not saline. The hazard of soil blowing is moderate on the Hamerly soil and slight on the Tonka soil. Runoff is slow on the Hamerly soil and ponded on the Tonka soil. In most areas of the Tonka soil, water ponds in spring and during periods of heavy rainfall. In most areas of this complex, small to large stones interfere with tillage. Most of the stones are on the Hamerly soil and are concentrated in the upper part of the soil.

Most areas of this complex are used for crops, but some areas are in grass that is cut for hay, used for pasture, or used for wildlife habitat. This complex is fairly well suited to farming, but it is not suited to trees in most areas. Controlling salinity, selecting salt-tolerant crops, removing excess water and stones, and controlling soil blowing are the main concerns of management. Capability unit IIIs–4L; Hamerly part in windbreak suitability group 10, Tonka part in windbreak suitability group 2.

Hecla Series

The Hecla series consists of deep, nearly level and gently sloping, moderately well drained soils. These soils are in broad areas, on narrow to broad beaches, and on breaks to drainageways and streams on the delta and between the beaches. They formed in moderately coarse textured and coarse textured glacial melt–water deposits.

In a representative profile the surface layer is black loamy fine sand about 14 inches thick. Below this is very dark grayish brown loamy fine sand about 6 inches thick. The underlying material is fine sand. The upper part is dark grayish brown, and the lower part is grayish brown mottled with yellowish brown.

Permeability is moderately rapid or rapid in and directly beneath the surface layer and rapid in the underlying material. The available water capacity is low. The organic-matter content is high, and fertility is medium. These soils have a deep water table.

Hecla soils are fairly well suited to farming in most areas and are well suited to trees. Most areas of this soil are used for crops, but some areas are in grass. The limitations for nonfarm uses are slight to severe.

Representative profile of Hecla loamy fine sand, 1 to 3 percent slopes, in a pasture, 93 feet west and 1,378 feet north of the southeast corner of sec. 5, T. 145 N., R. 53 W.

A1—0 to 14 inches, black (10YR 21) loamy fine sand, dark gray (10YR 4/1) when dry; weak fine granular structure; soft, very friable, slightly sticky and nonplastic; many roots and common pores; slightly acid; clear smooth boundary.

AC—14 to 20 inches, very dark grayish brown (10YR 3/2) loamy fine sand, grayish brown (10YR 5/2) when dry; weak medium prismatic structure; soft, very friable, slightly sticky and slightly plastic; common roots and pores; slightly acid; clear smooth boundary.

C1—20 to 46 inches, dark grayish brown (10YR 4/2) fine sand, light brownish gray (10YR 6/2) when dry; single grained; loose, nonsticky and nonplastic; few roots and common pores; slightly acid; gradual smooth boundary.

C2—46 to 60 inches, grayish brown (2.5Y 5/2) fine sand, light brownish gray (2.5Y6/2) when dry; few distinct yellowish brown mottles; single grained; loose, nonsticky and nonplastic; slightly acid.

The soil is slightly acid or neutral. A stone line is at a depth of 40 to 60 inches in a few places. The solum ranges from 16 to 38 inches in thickness. The A horizon ranges from 12 to 28 inches in thickness. It is black or very dark gray loamy sand to fine sandy loam. The AC horizon ranges from 4 to 10 inches in thickness. It is very dark gray or very dark grayish brown loamy fine sand or loamy sand.

The C horizon commonly is fine sand, loamy sand, or loamy fine sand, but below a depth of 40 inches, it is sand to silt loam. It is commonly mottled below a depth of 30 inches.

Helca soils formed in material similar to that in which the Hamar, Maddock, and Ulen soils formed. They are better drained than Hamar soils. They are darker colored to a greater depth than Maddock soils. They are better drained than Ulen soils and, unlike those soils, lack a calcareous A horizon.

HeA—Hecla loamy fine sand, 1 to 3 percent slopes. This nearly level soil is on beaches and in broad areas between the beaches and on the delta. It has the profile described as representative of the series. The surface layer is loamy fine sand in most places, but it is loamy sand in a few places.

Included with this soil in mapping are some areas of Hamar loamy fine sand, which makes up not more than 15 percent of this mapping unit, and Maddock loamy fine sand, which makes up not more than 10 percent. The Hamar soil is in shallow depressions and swales, and the Maddock soil is on plane and slightly convex side slopes. A few small areas that are steep and have short slopes are indicated by a spot symbol on the soil map.

Soil blowing is a very severe hazard. The available water capacity is low. Runoff is slow.

Most areas of this soil are used for crops, but some areas are in grass that is used for wildlife habitat, cut for hay, or used for pasture. This soil is poorly suited to farming but well suited to trees. Controlling soil blowing and conserving moisture are the main concerns of management. Capability unit IVe–2; windbreak suitability group 1.

HfA—Hecla fine sandy loam, 1 to 3 percent slopes. This nearly level soil is on narrow to broad beaches and in broad areas between the beaches and on the delta. It has a profile similar to the one described as representative of the series, but the surface layer is fine sandy loam. In a few places this soil is sandy loam instead of fine sandy loam.

Included with this soil in mapping are some areas of Hamar fine sandy loam, which makes up about 12 percent of this mapping unit, Ulen fine sandy loam, which makes up not more than 10 percent, and Maddock fine sandy loam, which makes up about 8 percent. The Hamar soil is in shallow depressions and swales, the Ulen soil is on slightly convex side slopes in low areas, and the Maddock soil is on crests of beaches and breaks. Also included are a few areas that contain a stone line within 3 feet of the surface. These areas are mainly on Hillsboro beach. Small wet areas and a few small areas that are steep and have short slopes are indicated by spot symbols on the soil map.

Soil blowing is a severe hazard. The available water capacity is low. Runoff is slow.

Nearly all areas of this soil are used for crops, but a few areas are in grass that is cut for hay or used for pasture. This soil is fairly well suited to farming and well suited to trees. Controlling soil blowing and conserving moisture are the main concerns of management. Capability unit IIIe–3; windbreak suitability group 1.

HmB—Hecla-Maddock sandy loams, 1 to 6 percent slopes. The soils of this complex are nearly level and gently sloping and are on beaches and breaks to drainageways and streams between the beaches and on the delta. The Hecla soil is on plane and slightly concave side slopes, and the Maddock soil is on plane and slightly convex side slopes. This complex is at least 50 percent Hecla sandy loam and is about 30 percent Maddock sandy loam.

In a few areas these soils have a surface layer of loamy sand and fine sandy loam instead of sandy loam. The Hecla soil has a profile similar to the one described as representative of the series, but the surface layer is sandy loam. The Maddock soil has the profile described as representative of the series.

Included with this complex in mapping are some areas of Arvilla sandy loam, which makes up not more than 10 percent of this mapping unit, Hamar sandy loam, which makes up not more than 5 percent, and Serden soils, which makes up not more than 5 percent. The Arvilla soil is on crests of beaches, The Hamar soil is in shallow depressions and swales, and the Serden soils are on crests of beaches. Also included in mapping are a few small areas where slopes are more than 6 percent and a few areas of soils that contain a stone line within 3 feet of the surface, mainly on Hillsboro Beach. A few small areas that are steep and have short slopes are indicated by a spot symbol on the soil map.

Soil blowing is a severe hazard, and water erosion is a moderate hazard. The available water capacity is low. Runoff is slow.

Nearly all areas of this complex are used for crops, but a few areas are in grass that is cut for hay or used for pasture. This complex is fairly well suited to farming and well suited to trees. Controlling soil blowing, improving and maintaining fertility and organic-matter content, conserving moisture, and controlling water erosion are the main concerns of management. Capability unit IIIe–3; Hecla part in windbreak suitability group 1, Maddock part in windbreak suitability group 5.

Hegne Series

The Hegne series consists of deep, nearly level, poorly drained soils. These soils are in broad areas on the glacial lake plain. They formed in fine textured glacial lacustrine deposits.

In a representative profile the surface layer is very dark gray silty clay about 9 inches thick. The underlying material, to a depth of 27 inches, is silty clay that has an accumulation of lime. It is light olive gray and olive gray and mottled with yellowish brown. Below this is olive gray silty clay mottled with yellowish brown.

Permeability is slow, and the available water capacity is high. The organic-matter content is high, and fertility is medium. These soils have a seasonal water table 1 to 3 feet below the surface.

Hegne soils are well suited to farming and to trees. Nearly all areas of these soils are used for crops, but a few areas are in grass. The limitations for most nonfarm uses are severe.

Representative profile of Hegne silty clay, in an area of Hegne-Enloe silty clays, in a cultivated field, 720 feet south and 111 feet east of the northwest corner of sec. 24, T. 144 N., R. 50 W.

Ap—0 to 9 inches, very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) when dry; weak fine gran-

ular structure; slightly hard, firm, very sticky and very plastic; many roots and pores; slightly effervescent; mildly alkaline; abrupt smooth boundary.

C1gca—9 to 18 inches, light olive gray (5Y 6/2) silty clay, light gray (5Y 7/1) when dry; weak medium prismatic structure parting to moderate fine blocky; hard, firm, very sticky and very plastic; common roots and many pores; violently effervescent; mildly alkaline; gradual wavy boundary.

C2gca—18 to 27 inches, olive gray (5Y 5/2) silty clay, light gray (5Y 7/2) when dry; few fine faint yellowish brown mottles; weak medium prismatic structure parting to moderate fine blocky; hard, firm, very sticky and very plastic; common roots and many pores; violently effervescent; mildly alkaline; gradual wavy boundary.

C3g—27 to 44 inches, olive gray (5Y 5/2) silty clay, light gray (5Y 7/2) when dry; common medium distinct yellowish brown (10YR 5/6) mottles; moderate fine blocky structure; very hard, firm, very sticky and very plastic; few roots and common pores; strongly effervescent; mildly alkaline; gradual wavy boundary.

C4g—44 to 60 inches, olive gray (5Y 5/2) silty clay, light olive gray (5Y 6/2) when dry; common medium prominent yellowish brown (10YR 5/6) mottles; moderate fine and medium blocky structure; very hard, firm, very sticky and very plastic; slightly effervescent; mildly alkaline.

This soil is silty clay or clay throughout. It is mildly alkaline or moderately alkaline. The A horizon ranges from 7 to 12 inches in thickness and is black or very dark gray. Thin tongues of material from the A horizon extend to a depth of 28 inches in some places. The Cgca horizon ranges from 8 to 18 inches in thickness and is dark gray to light olive gray. In the Cg horizon in some places, gypsum crystals and other salts are common.

Hegne soils formed in material similar to that in which the Dovray, Enloe, and Fargo soils formed. They are better drained than Dovray soils and, unlike those soils, have a layer where lime has accumulated within 16 inches of the surface. They lack a platy A2 horizon and a B horizon, which Enloe soils have. They have a calcareous A horizon and, unlike Fargo soils, lack a B horizon.

Hn—Hegne-Enloe silty clays. The soils of this complex are nearly level and are in broad areas on the glacial lake plain. The Hegne soil is on convex slopes, and the Enloe soil is in small, shallow depressions. This complex is at least 58 percent Hegne silty clay and is about 27 percent Enloe silty clay. Slopes are 0 to 1 percent.

The Hegne soil has the profile described as representative of the series. The Enloe soil has a profile similar to the one described as representative of the series, but the surface layer is silty clay in most places. In a few areas the surface layer is silty clay loam instead of silty clay.

Included with this complex in mapping are some areas of Fargo silty clay, which makes up not more than 15 percent of this mapping unit. This soil is on plane slopes. A few small areas that are steep and have short slopes are indicated by a spot symbol on the soil map.

Soil blowing is a moderate hazard. Runoff is slow on the Hegne soil and ponded on the Enloe soil. In most years water ponds on the Enloe soil in spring and during periods of heavy rainfall.

Nearly all areas of this complex are used for crops, but a few areas are in grass that is used for pasture. This soil is well suited to farming and to trees if excess water is removed. Controlling soil blowing, removing excess water, and maintaining tilth and permeability are the main concerns of management. Capability unit IIew–4; Hegne part in windbreak suitability group 1, Enloe part in windbreak suitability group 2.

Ho—Hegne-Fargo silty clays. The soils of this complex are nearly level and are in broad areas on the glacial lake plain. The Hegne soil is on convex and plane slopes, and the Fargo soil is on plane and slightly concave slopes. This complex is about 60 percent Hegne silty clay and about 30 percent Fargo silty clay. Slopes are 0 to 1 percent. In a few places these soils have a surface layer of clay instead of silty clay.

Included with this complex in mapping are some areas of Enloe silty clay, Dovray silty clay, or both, which make up not more than 10 percent of this mapping unit. These soils are in shallow swales or depressions. A few small wet areas and a few small areas that are steep and have short slopes are indicated by spot symbols on the soil map.

Soil blowing is a moderate hazard. Runoff is very slow on the Fargo soil and slow on the Hegne soil. In a few areas water ponds on the Fargo soil for short periods in spring during periods when rainfall is heavy and snow melts rapidly.

Nearly all areas of this complex are used for crops, but a few areas are in grass that is used for pasture. This complex is well suited to farming and to trees. Controlling soil blowing, removing excess water, and maintaining tilth and permeability are the main concerns of management. Capability unit IIew–4; windbreak suitability group 1.

Heimdal Series

The Heimdal series consists of deep, nearly level to rolling, well drained soils. These soils are in areas on the glacial till plain. They formed in medium textured and moderately coarse textured water-worked glacial till.

In a representative profile the surface layer is black loam about 7 inches thick. The subsoil is loam about 14 inches thick. The upper part is dark grayish brown, and the lower part is brown. The underlying material, to a depth of 33 inches, is light olive brown loam that has an accumulation of lime. Below this is light olive brown very fine sandy loam mottled with very dark gray.

Permeability is moderate, and the available water capacity is high. The organic-matter content is high, and fertility is medium. These soils have a deep water table.

Heimdal soils are well suited to farming in most areas and well suited to trees. Nearly all areas of these soils are used for crops, but a few areas are in grass. The limitations are slight for most nonfarm uses.

Representative profile of Heimdal loam, in an area of Heimdal-Esmond loams, 6 to 9 percent slopes, in a cultivated field, 159 feet north and 195 feet east of the southwest corner of sec. 19, T. 144 N., R. 53 W.

Ap—0 to 7 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) when dry; weak medium subangular blocky structure parting to weak fine crumb; soft, very friable, slightly sticky and slightly plastic; common roots and pores; neutral; abrupt smooth boundary.

B21—7 to 14 inches, dark grayish brown (10YR 4/2) loam, brown (10YR 5/3) when dry; moderate medium and coarse prismatic structure parting to weak

medium and coarse blocky; slightly hard, very friable, slightly sticky and slightly plastic; common roots and pores; neutral; clear and wavy boundary.

B22—14 to 21 inches, brown (10YR 4/3) loam, pale brown (10YR 6/3) when dry; moderate medium and coarse prismatic structure parting to weak coarse blocky; slightly hard, very friable, slightly sticky and slightly plastic; common roots and pores; neutral; clear wavy boundary.

C1ca—21 to 33 inches, light olive brown (2.5Y 5/4) loam, light gray (2.5Y 7/2) when dry; weak coarse prismatic structure parting to weak coarse blocky; slightly hard, very friable, slightly sticky and slightly plastic; few roots and common pores; violently effervescent; mildly alkaline; gradual wavy boundary.

C2—33 to 60 inches, light olive brown (2.5Y 5/4) very fine sandy loam, pale yellow (2.5Y 7/4) when dry; few medium distinct very dark gray (10YR 3/1) mottles; weak coarse subangular blocky structure; soft, very friable, slightly sticky and slightly plastic; slightly effervescent; mildly alkaline.

These soils are 2 to 10 percent rock fragments. The solum ranges from 14 to 22 inches in thickness. The A horizon ranges from 5 to 8 inches in thickness. It is black or very dark gray loam or very fine sandy loam. The B horizon ranges from 9 to 14 inches in thickness and is very dark grayish brown to yellowish brown. The C horizon is loam, silt loam, or very fine sandy loam that has pockets of sand and silt. It is mildly alkaline or moderately alkaline and slightly to violently effervescent.

Heimdal soils are near the Emrick, Esmond, and Lankin soils. They are lighter colored nearer the surface than Emrick soils. They have a B horizon, which is lacking in Esmond soils. They contain less clay in the C horizon than Lankin soils.

HrB—Heimdal-Emrick loams, 3 to 6 percent slopes. The soils of this complex are undulating and are on the glacial till plain. Slopes generally are short. The Heimdal soil is on plane and convex upper side slopes, and the Emrick soil is on plane and concave lower side slopes. This complex is about 65 percent Heimdal loam and about 30 percent Emrick loam.

Included with this complex in mapping are some areas of Esmond loam, which makes up not more than 5 percent of this mapping unit. This soil is on crests of knolls and ridges. A few small wet areas are indicated by a spot symbol on the soil map.

Runoff is medium on the Heimdal soil and slow on the Emrick soil. The hazards of water erosion and soil blowing are moderate.

Nearly all areas of this complex are used for crops, but a few areas are in grass that is used for pasture. This complex is well suited to farming and to trees. Controlling water erosion and soil blowing and conserving moisture are the main concerns of management. Capability unit IIe–5; Heimdal part in windbreak suitability group 3, Emrick part in windbreak suitability group 1.

HsC—Heimdal-Esmond loams, 6 to 9 percent slopes. The soils of this complex are rolling and are on the glacial till plain. Slopes generally are short. The Heimdal soil is on plane and lower convex side slopes, and the Esmond soil is on upper convex side slopes. This complex is at least 60 percent Heimdal loam and at least 30 percent Esmond loam. The Heimdal and Esmond soils have the profiles described as representative of their respective series.

Included with this complex in mapping are some areas of Emrick loam, which makes up not more than 10 percent of this mapping unit. This soil is on slightly concave side slopes. A few small areas that are steep and have short slopes are indicated by a spot symbol on the soil map.

Soil blowing is a moderate hazard, and water erosion is a severe hazard. Runoff is medium on the Heimdal soil and rapid on the Esmond soil.

Most areas of this complex are used for crops, but a few areas are in grass that is cut for hay or used for pasture. This complex is fairly well suited to farming and, in most areas, well suited to trees. Controlling water erosion and soil blowing, conserving moisture, and improving fertility are the main concerns of management. Capability unit IIIe–5; Heimdal part in windbreak suitability group 3, Esmond part in windbreak suitability group 8.

LaDelle Series

The LaDelle series consists of deep, nearly level, moderately well drained soils. These soils are on terraces and flood plains along streams. They formed in moderately fine textured alluvium deposited by streams.

In a representative profile the surface layer is silty clay loam about 32 inches thick. The upper part is very dark gray, the middle part is black, and the lower part is very dark gray. The underlying material, to a depth of about 54 inches, is grayish brown silty clay loam. Below this is a buried surface layer of black silty clay loam about 2 inches thick. This layer is underlain by olive gray silty clay loam.

Permeability is moderate, and the available water capacity is high. The organic-matter content and fertility are high. These soils have a low water table and are subject to flooding by streams.

LaDelle soils are well suited to farming and to trees. Most areas of these soils are used for crops, but a few areas are in grass and native woodland. The limitations for many nonfarm uses are moderate and severe.

Representative profile of LaDelle silty clay loam, in a cultivated field, 1,450 feet west and 156 feet south of the northeast corner of sec. 34, T. 147 N., R. 52 W.

Ap—0 to 7 inches, very dark gray (10YR 3/1) silty clay loam, dark gray (10YR 4/1) when dry; weak medium subangular blocky structure parting to weak fine granular; slightly hard, friable, sticky and plastic; common roots and pores; slightly effervescent; neutral; abrupt smooth boundary.

A11—7 to 10 inches, very dark gray (10YR 3/1) silty clay loam, dark gray (10YR 4/1) when dry; weak medium blocky structure parting to weak fine granular; slightly hard, friable, sticky and plastic; common roots and pores; slightly effervescent; neutral; clear wavy boundary.

A12—10 to 19 inches, black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) when dry; weak medium subangular blocky structure parting to weak fine granular; slightly hard, friable, sticky and plastic; few roots and common pores; slightly effervescent; neutral; gradual wavy boundary.

A13—19 to 32 inches, very dark gray (10YR 3/1) silty clay loam, dark gray (10YR 4/1) when dry; weak medium subangular blocky structure parting to weak fine granular; slightly hard, friable, sticky and plastic; few roots and common pores; strongly effervescent; neutral; gradual wavy boundary.

C1—32 to 54 inches, grayish brown (2.5Y 5/2) silty clay loam, light brownish gray (2.5Y 6/2) when dry; few fine distinct very dark grayish brown mottles; weak medium and coarse subangular blocky struc-

ture; hard, friable, sticky and plastic; strongly effervescent; neutral; clear smooth boundary.

A1b—54 to 56 inches, black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) when dry; weak medium and coarse subangular blocky structure; hard, friable, sticky and plastic; strongly effervescent; neutral; clear smooth boundary.

C2—56 to 60 inches, olive gray (5Y 4/2) silty clay loam, light olive gray (5Y 6/2) when dry; few fine distinct very dark grayish brown mottles; massive; hard, friable, sticky and plastic; strongly effervescent; neutral.

These soils are neutral or mildly alkaline and are calcareous within 20 inches of the surface. They are commonly silty clay loam but in a few areas they are silt loam or, in some places below a depth of 40 inches, silty clay. The A horizon ranges from 20 to 40 inches in thickness. The C horizon is dark gray to pale brown. Buried A horizons commonly occur below a depth of 24 inches. Mottles range from few to many and faint to prominent.

LaDelle soils are near the Fairdale, Lamoure, and La Prairie soils. They have a darker colored A horizon than Fairdale soils. They are better drained than Lamoure soils. They contain less sand and more clay than La Prairie soils.

La—LaDelle silty clay loam. This nearly level soil is on terraces and flood plains along streams. It has the profile described as representative of the series. It is silty clay loam in most areas, but it is silt loam throughout the profile in a few areas. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Fairdale silty clay loam, which makes up not more than 15 percent of this mapping unit, and Lamoure soils, which make up not more than 10 percent. The Fairdale soil is on the lower parts of flood plains, and the Lamoure soils are in abandoned stream channels. A few small saline areas and a few areas that are steep and have short slopes are indicated by spot symbols on the soil map.

Runoff is slow. In some years this soil is subject to flooding by streams in spring during periods when rainfall is heavy and snow melts rapidly.

Most areas of this soil are used for crops, but a few areas are in grass and native woodland that are used for pasture or wildlife habitat. This soil is well suited to farming and to trees. Conserving moisture and maintaining tilth, permeability, fertility, and organic-matter content are the main concerns of management. Capability unit IIc–6; windbreak suitability group 1.

Lamoure Series

The Lamoure series consists of deep, nearly level, poorly drained soils. These soils are in abandoned channels and on low flood plains in drainageways and along streams. They formed in medium textured alluvium.

In a representative profile the surface layer is silt loam about 35 inches thick. The upper part is black, the middle part is very dark gray, and the lower part is black and mottled with dark yellowish brown. The upper part of the underlying material is very dark grayish brown loam mottled with dark gray. The lower part is a buried surface layer that is black silty clay loam mottled with brown.

Permeability is moderate, and the available water capacity is high. The organic-matter content is high, and fertility is medium. These soils have a seasonal high water table 1 to 3 feet below the surface. They are subject to flooding by streams.

Lamoure soils are well suited to farming and to trees if excess water is removed. Nearly all areas of these soils are in grass, but a few areas are used for crops. The limitations for many nonfarm uses are severe.

Representative profile of Lamoure silt loam, in a pasture, 123 feet east and 1,186 feet north of the southwest corner of sec. 5, T. 144 N., R. 53 W.

A11—0 to 16 inches, black (10YR 2/1) silt loam, very dark gray (10YR 3/1) when dry; weak medium granular structure; slightly hard, friable, slightly sticky and plastic; many roots and few pores; strongly effervescent; mildly alkaline; clear wavy boundary.

A12—16 to 21 inches, very dark gray (2.5Y 3/1) silt loam, dark gray (10YR 4/1) when dry; weak coarse prismatic structure parting to weak medium granular; slightly hard, friable, slightly sticky and plastic; common roots and pores; strongly effervescent; mildly alkaline; clear smooth boundary.

A13—21 to 35 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) when dry; common fine distinct dark yellowish brown (10YR 4/4) mottles; weak coarse prismatic structure parting to weak medium granular; slightly hard, friable, slightly sticky and plastic; common roots and pores; strongly effervescent; mildly alkaline; gradual wavy boundary.

Cg—35 to 55 inches, very dark grayish brown (2.5Y 3/2) loam, grayish brown (2.5Y 5/2) when dry; common medium distinct dark gray (5Y 4/1) mottles; weak coarse subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; strongly effervescent; mildly alkaline; clear smooth boundary.

A1b—55 to 60 inches, black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) when dry; many medium distinct brown (10YR 4/3) mottles; weak fine subangular blocky structure; hard, friable, sticky and plastic; slightly effervescent; mildly alkaline.

The solum ranges from 24 to 36 inches in thickness. These soils are commonly silt loam, but in a few areas they are silty clay loam or, in some places below a depth of 40 inches, silty clay to sand. They are mildly alkaline or moderately alkaline and are calcareous within 10 inches of the surface. The A horizon ranges from 12 to 36 inches in thickness. The Cg horizon is very dark gray to dark grayish brown. Buried A horizons commonly are below a depth of 36 inches. Mottles range from few to many and faint to prominent.

Lamoure soils are near the Fairdale, LaDelle, and La Prairie soils. They are more poorly drained and have a darker colored A horizon than Fairdale soils. They are more poorly drained than LaDelle soils. They contain more silt and less sand and are more poorly drained than La Prairie soils.

Lm—Lamoure silt loam. This nearly level soil is in abandoned channels and on low flood plains in drainageways and along streams. It has the profile described as representative of the series. It is silt loam in most areas, but it is silty clay loam throughout the profile in a few areas. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Playmoor silty clay loam, which makes up not more than 10 percent of this mapping unit, and La Prairie silt loam, which makes up not more than 10 percent. The La Prairie soil is on terraces and higher parts of the flood plain. Also included in mapping are a few small areas that are more poorly drained than is representative of the Lamoure soils. A few small saline areas are indicated by a spot symbol on the soil map.

Runoff is slow. This soil is subject to flooding by streams in spring and during periods of heavy rainfall. A seasonal high water table is near the surface in spring and during periods of heavy rainfall.

Nearly all areas of this soil are in grass that is used for wildlife food and cover, cut for hay, or used for pasture. A few areas are used for late seeded crops. This soil is well suited to farming and to trees if excess water is removed. Removing excess water, improving fertility, and maintaining high-quality vegetation for hay and pasture are the main concerns of management. Capability unit IIw–4L; windbreak suitability group 2.

Lankin Series

The Lankin series consists of deep, nearly level, moderately well drained soils. These soils are in areas between the beaches. They formed in medium textured glacial melt-water deposits and the underlying medium textured and moderately fine textured water-worked glacial till.

In a representative profile the surface layer is black loam about 10 inches thick. The subsoil, about 20 inches thick, is very dark gray loam in the upper part. The lower part is dark grayish brown clay loam mottled with yellowish brown. The underlying material, to a depth of 39 inches, is light brownish gray clay loam that has an accumulation of lime and that is mottled with yellowish brown. Below this is grayish brown clay loam mottled with yellowish brown.

Permeability is moderate in the surface layer and subsoil and moderately slow in the underlying material. The available water capacity is high. The organic-matter content and fertility are high. These soils have a seasonal water table 3 to 5 feet below the surface.

Lankin soils are well suited to farming and to trees. Nearly all areas of these soils are used for crops, but a few areas are in grass. The limitations for many nonfarm uses are slight to severe.

Representative profile of Lankin loam, in a cultivated field, 93 feet north and 1,404 feet west of the southwest corner of sec. 19, T. 145 N., R. 53 W.

Ap—0 to 7 inches, black (10YR 2/1) loam, very dark gray (10YR 3/1) when dry; weak fine granular structure; slightly hard, friable, slightly sticky and slightly plastic; many roots and common pores; neutral; abrupt smooth boundary.

A12—7 to 10 inches, black (10YR 2/1) loam, very dark gray (10YR 3/1) when dry; weak medium blocky structure parting to weak fine granular; slightly hard, friable, slightly sticky and slightly plastic; many roots and common pores; neutral; gradual smooth boundary.

B2—10 to 21 inches, very dark gray (10YR 3/1) loam, dark gray (10YR 4/1) when dry; moderate medium prismatic structure parting to moderate medium blocky; slightly hard, friable, slightly sticky and slightly plastic; common roots and pores; neutral; clear smooth boundary.

IIB3—21 to 30 inches, dark grayish brown (2.5Y 4/2) clay loam, light brownish gray (2.5Y 6/2) when dry; few medium faint yellowish brown (10YR 5/4) mottles; moderate medium prismatic structure parting to weak medium blocky; hard, firm, sticky and plastic; common roots and pores; slightly effervescent; neutral; clear wavy boundary.

IIC1ca—30 to 39 inches, light brownish gray (2.5Y 6/2) clay loam, white (2.5Y 8/2) when dry; few medium distinct yellowish brown (10YR 5/4) mottles; weak fine blocky structure; hard, firm, sticky and plastic; few roots and common pores; violently effervescent; mildly alkaline; gradual wavy boundary.

IIC2—39 to 60 inches, grayish brown (2.5Y 5/2) clay loam, light gray (2.5Y 7/2) when dry; many medium distinct yellowish brown (10YR 5/6) mottles; massive; hard, firm, sticky and plastic; strongly effervescent; mildly alkaline.

The solum ranges from 20 to 30 inches in thickness. The A horizon ranges from 7 to 10 inches in thickness and is loam or silt loam. The B2 horizon ranges from 8 to 11 inches in thickness. It is very dark gray or very dark grayish brown loam or silt loam. The IIB horizon ranges from 5 to 9 inches in thickness. It is very dark grayish brown or dark grayish brown loam, silt loam, or clay loam. This horizon is neutral or mildly alkaline. The IIC horizon is dark grayish brown to light yellowish brown firm loam or clay loam. It is mildly alkaline or moderately alkaline.

Lankin soils are near the Gilby, Hamerly, and Tonka soils. They are better drained than Gilby and Hamerly soils but they lack a layer where lime has accumulated within 16 inches of the surface. They are better drained than Tonka soils, but they lack a platy A2 horizon.

Ln—Lankin loam. This nearly level soil is in areas between the beaches. It has the profile described as representative of the series. The surface layer is loam in most places, but it is silt loam in a few places. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Gilby loam, which makes up not more than 15 percent of this mapping unit, and Tonka silt loam, which makes up not more than 5 percent. The Gilby soil is on slightly convex slopes, and the Tonka soil is in small, shallow depressions. Small wet areas, small saline areas, and a few areas that are steep and have short slopes are indicated by spot symbols on the soil map.

Soil blowing is a slight hazard. In some areas a few small to large stones interfere with tillage. Runoff is slow.

Nearly all areas of this soil are used for crops, but a few areas are in grass that is cut for hay or used for pasture. This soil is well suited to farming and to trees. Conserving moisture and removing stones are the main concerns of management. Capability unit IIc–6; windbreak suitability group 1.

La Prairie Series

The La Prairie series consists of deep, moderately well drained, nearly level soils. These soils are on low terraces and high flood plains on bottom lands along streams. They formed in medium textured alluvium deposited by streams.

In a representative profile the surface layer is silt loam about 31 inches thick. The upper part of the surface layer is black, the middle part is very dark gray and the lower part is black. The underlying material, to a depth of about 44 inches, is dark grayish brown silt loam. The next layer is black silt loam, about 12 inches thick, and below this is dark grayish brown silt loam.

Permeability is moderate, and the available water capacity is high. The organic-matter content and fertility are high. These soils have a deep water table and are subject to flooding by streams.

La Prairie soils are well suited to farming and to trees. Most areas of these soils are used for crops, but some areas are in grass and native woodland. The

limitations for many nonfarm uses are moderate and severe.

Representative profile of La Prairie silt loam, in a cultivated field, 1,460 feet north and 30 feet west of the southeast corner of sec. 31, T. 147 N., R. 53 W.

Ap—0 to 8 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) when dry; weak medium subangular blocky structure parting to weak medium granular; slightly hard, friable, slightly sticky and slightly plastic; common roots and many pores; mildly alkaline; abrupt smooth boundary.

A12—8 to 15 inches, very dark gray (10YR 3/1) silt loam, gray (10YR 5/1) when dry; weak coarse prismatic structure parting to weak coarse blocky; slightly hard, friable, slightly sticky and slightly plastic; common roots and many pores; mildly alkaline; clear smooth boundary.

A13—15 to 31 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) when dry; weak coarse prismatic structure parting to weak coarse blocky; slightly hard, friable, slightly sticky and slightly plastic; common roots and many pores; mildly alkaline; gradual smooth boundary.

C1—31 to 44 inches, dark grayish brown (10YR 4/2) silt loam, grayish brown (2.5Y 5/2) when dry; weak coarse blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few roots and common pores; slightly effervescent; mildly alkaline; abrupt smooth boundary.

A1b—44 to 56 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) when dry; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; slightly effervescent; mildly alkaline; gradual smooth boundary.

C2—56 to 60 inches, dark grayish brown (2.5Y 4/2) silt loam, grayish brown (2.5Y 5/2) when dry; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; slightly effervescent; mildly alkaline.

These soils are neutral or mildly alkaline. The A horizon ranges from 16 to 60 inches in thickness, but is 20 to 40 inches thick in most places. It is commonly silt loam, but it is loam in some places. Below a depth of 24 inches, one or more buried horizons are common. The C horizon is dark gray to grayish brown loam or silt loam.

La Prairie soils are near the Fairdale, LaDelle, and Lamoure soils. They are darker colored to a greater depth than Fairdale soils. They contain more sand than LaDelle soils. They are better drained than Lamoure soils.

Lp—La Prairie silt loam. This nearly level soil is on low terraces and high flood plains along streams. It has the profile described as representative of the series. The surface layer is silt loam in most places, but it is loam in a few places. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Fairdale silt loam, which makes up not more than 15 percent of this mapping unit, and Lamoure silt loam, which makes up not more than 5 percent. The Fairdale soil is on the lower parts of the bottom lands, and the Lamoure soil is in abandoned stream channels. Also included in mapping are small areas where slopes are 3 to 6 percent. A few small areas that are steep and have short slopes are indicated by a spot symbol on the soil map.

This soil is subject to flooding by streams for short periods in spring during periods when rainfall is heavy and snow melts rapidly. Runoff is slow.

Most areas of this soil are used for crops, but some areas are in grass and native woodland that are used for wildlife habitat, cut for hay, or used for pasture. This soil is well suited to farming and to trees. Conserving moisture and maintaining fertility and high-quality vegetation for hay and pasture are the main concerns of management. Capability unit IIc–6; windbreak suitability group 1.

Lindaas Series

The Lindaas series consists of deep, poorly drained, nearly level soils. These soils are in shallow depressions and narrow, shallow swales on the glacial lake plain. They formed in medium textured to fine textured glacial lacustrine deposits.

In a representative profile the surface layer is black silty clay loam about 15 inches thick. The subsoil is very dark gray silty clay about 12 inches thick. The underlying material, to a depth of 37 inches, is light brownish gray silty clay loam that has an accumulation of lime and is mottled with very dark gray and yellowish brown. Below this is light olive gray silt loam mottled with very dark gray and strong brown.

Permeability is slow, and the available water capacity is high. The organic-matter content and fertility are high. These soils have a high water table 1 to 3 feet below the surface.

Lindaas soils are well suited to farming and to trees if excess water is removed. All areas of these soils are used for crops. The limitations for most nonfarm uses are severe.

Lindaas soils are mapped only in complex with Bearden soils.

Representative profile of Lindaas silty clay loam, in an area of Bearden-Lindaas silty clay loams, in a cultivated field, 1,745 feet west and 290 feet north of the southeast corner of sec. 4, T. 144 N., R. 49 W.

Ap—0 to 7 inches, black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) when dry; weak medium subangular blocky structure parting to moderate fine granular; slightly hard, friable, sticky and plastic; common roots and pores; neutral; abrupt smooth boundary.

A12—7 to 15 inches, black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) when dry; weak coarse subangular blocky structure parting to moderate medium platy; hard, friable, sticky and plastic; common roots and common pores; neutral; clear wavy boundary.

B2t—15 to 27 inches, very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) when dry; moderate medium prismatic structure parting to moderate fine blocky; hard, firm, very sticky and very plastic; few roots and pores; organic stains and clay films on faces of prisms and blocks; mildly alkaline; clear irregular boundary.

C1ca—27 to 37 inches, light brownish gray (2.5Y 6/2) silty clay loam, light gray (2.5Y 7/2) when dry; few fine distinct very dark gray mottles and few fine distinct yellowish brown mottles; weak coarse prismatic structure; slightly hard, friable, sticky and plastic; violently effervescent; moderately alkaline; gradual wavy boundary.

C2g—37 to 60 inches, light olive gray (5Y 6/2) silt loam, light gray (5Y 7/2) when dry; few fine distinct very dark gray mottles and many medium prominent strong brown (7.5YR 5/6) mottles; weak very coarse prismatic structure parting to weak medium platy; slightly hard, friable, slightly sticky and slightly plastic; slightly effervescent; moderately alkaline.

The solum ranges from 24 to 40 inches in thickness. The A horizon ranges from 9 to 17 inches in thickness. It is black or very dark gray silt loam or silty clay loam. The B horizon ranges from 10 to 23 inches in thickness. It is very dark gray to grayish brown clay or silty clay. The

lower part of the B horizon is calcareous and has few to common and faint to distinct mottles in some places. The C horizon is commonly silt loam or silty clay loam, but below a depth of 40 inches, clayey material may occur in some places. This horizon is mildly alkaline or moderately alkaline.

Lindaas soils formed in material similar to that in which the Bearden, Colvin, and Overly soils formed. They are more poorly drained than Bearden soils and have a noncalcareous B horizon, which is lacking in those soils. Unlike Colvin soils, Lindaas soils lack a layer where lime has accumulated within 16 inches of the surface. They are more poorly drained and contain more clay in the B horizon than Overly soils.

Ludden Series

The Ludden series consists of deep, poorly drained, nearly level soils. These soils are in drainageways, in abandoned channels, and on low flood plains along streams. They formed in fine textured alluvium deposited by streams.

In a representative profile the surface layer is black silty clay about 43 inches thick. The underlying material is dark gray silty clay mottled with dark yellowish brown.

Permeability is slow, and the available water capacity is high. The organic-matter content and fertility are high. These soils are subject to flooding by streams. They have a high water table 1 to 3 feet below the surface.

Ludden soils are fairly well suited to farming if excess water is removed, but they are not suited to trees. Nearly all areas of these soils are in grass, but a few areas are used for crops. The limitations for many nonfarm uses are severe.

Representative profile of Ludden silty clay, in grass, 2,126 feet north and 2,000 feet west of the southeast corner of sec. 11, T. 145 N., R. 52 W.

A11—0 to 8 inches, black (10YR 2/1) silty clay, dark gray (10YR 4/1) when dry; moderate medium blocky structure parting to weak medium granular; very hard, firm, very sticky and very plastic; many roots and common pores; slightly effervescent; mildly alkaline; clear smooth boundary.

A12—8 to 32 inches, black (10YR 2/1) silty clay, dark gray (10YR 4/1) when dry; moderate fine blocky structure; very hard, firm, very sticky and very plastic; common roots and many pores; slightly effervescent; mildly alkaline; clear smooth boundary.

A13—32 to 43 inches, black (10YR 2/1) silty clay, very dark gray (10YR 3/1) when dry; moderate fine blocky structure; very hard, firm, very sticky and very plastic; common roots and many pores; common small nests of gypsum crystals; few fine crystals of salt in lower part; slightly effervescent; mildly alkaline; clear smooth boundary.

Cgca—43 to 60 inches, dark gray (5Y 4/1) silty clay, gray (5Y 6/1) when dry; few distinct dark yellowish brown mottles; massive; very hard, firm, very sticky and very plastic; common small nests of gypsum crystals; violently effervescent; mildly alkaline.

The A horizon ranges from 24 to 48 inches in thickness. It is black or very dark gray clay or silty clay. This soil is moderately saline below a depth of 24 inches in some places. It is mildly alkaline or moderately alkaline. The A horizon has a coefficient of linear extensibility of 0.09 or more. The C horizon is very dark gray to olive gray clay or silty clay and has few to many, faint to prominent mottles.

Ludden soils are near the Cashel, Fargo, and Wahpeton soils. They are darker colored and more poorly drained than Cashel soils. They are darker colored to a greater depth than Fargo soils. They are more poorly drained than Wahpeton soils.

Lu—Ludden silty clay. This nearly level soil is in drainageways and abandoned channels and on low flood plains along streams. It has the profile described as representative of the series. It is silty clay in most places, but it is clay in a few places. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Cashel silty clay, which makes up not more than 15 percent of this mapping unit. This soil is on higher parts of the flood plains. Also included in mapping are small areas of Ludden silty clay that is moderately saline at the surface.

This soil is subject to flooding by streams in spring during periods when rainfall is heavy and snow melts rapidly. Runoff is very slow or ponded. In some areas water ponds in spring during periods when rainfall is heavy and snow melts rapidly.

Nearly all areas of this soil are in grass that is used for wildlife habitat, cut for hay, or used for pasture. A few areas are used for late seeded crops. This soil is fairly well suited to farming if excess water is removed, but it is not suited to trees. Removing excess water, maintaining permeability and tilth for crops, and maintaining high-quality vegetation for hay and pasture are the main concerns of management. Capability unit IIIw–4; windbreak suitability group 10.

Maddock Series

The Maddock series consists of deep, well drained, nearly level and gently sloping soils. These soils are on beaches and breaks to drainageways and streams on the delta and between the beaches. They formed in moderately coarse textured and coarse textured glacial melt-water deposits that have been reworked by wind in some places.

In a representative profile the surface layer is sandy loam about 11 inches thick. The upper part is very dark gray, and the lower part is black. The subsoil is dark brown loamy sand about 14 inches thick. The underlying material is dark grayish brown fine sand.

Permeability is rapid, and the available water capacity is low. The organic-matter content is moderate, and fertility is low. These soils have a deep water table.

Maddock soils are fairly well suited to farming in most places and are well suited to trees. Most areas of these soils are used for crops, but some areas are in grass. The limitations for nonfarm uses are slight to severe.

Maddock soils are mapped only in a complex with Hecla and Serden soils.

Representative profile of Maddock sandy loam, in an area of Hecla-Maddock sandy loams, 1 to 6 percent slopes, in a cultivated field, 440 feet south and 810 feet west of the northeast corner of sec. 29, T. 144 N., R. 52 W.

Ap—0 to 5 inches, very dark gray (10YR 3/1) sandy loam, dark gray (10YR 4/1) when dry; weak fine crumb structure; soft, very friable, nonsticky and nonplastic; common roots and pores; neutral; abrupt smooth boundary.

A12—5 to 11 inches, black (10YR 2/1) sandy loam, dark gray (10YR 4/1) when dry; weak fine crumb

structure; soft, very friable, nonsticky and nonplastic; few roots and common pores; neutral; clear wavy boundary.

B2—11 to 25 inches, dark brown (10YR 3/3) loamy sand, brown (10YR 5/3) when dry; single grained; loose, nonsticky and nonplastic; few roots and common pores; neutral; gradual wavy boundary.

C—25 to 60 inches, dark grayish brown (2.5Y 4/2) fine sand, light brownish gray (2.5Y 6/2) when dry; single grained; loose, nonsticky and nonplastic; mildly alkaline.

The A horizon ranges from 10 to 16 inches in thickness. It is slightly acid or neutral. It is black or very dark gray fine sandy loam to loamy sand. The B horizon ranges from 5 to 16 inches in thickness. It is very dark grayish brown, very dark brown, or dark brown loamy sand, loamy fine sand or fine sand. The C horizon is neutral or mildly alkaline. It is dark grayish brown or brown loamy sand, loamy fine sand, or fine sand. In some places a thin layer of pebbles or stones is below a depth of 40 inches.

Maddock soils formed in material similar to that in which the Hamar, Hecla, and Serden soils formed. Maddock soils are better drained than Hamar soils, but they lack mottles so near the surface. They have a thinner A horizon than Hecla soils. They are darker colored to a greater depth than Serden soils.

Marsh

Marsh (Ma) is a land type that consists of small, shallow lakes and depressions that are wet most of the year. The vegetation is bulrushes, cattails, reeds, and other aquatic plants that have little or no value as livestock feed (fig. 11). These areas can be used as a habitat for wildlife. Capability unit VIIIw–6; windbreak suitability group 10.

Nahon Series

The Nahon series consists of deep, somewhat poorly drained, nearly level soils that have a claypan. These soils are on the delta and between the beaches. They formed in medium textured to fine textured glacial lacustrine deposits.

In a representative profile the surface layer is black silt loam about 8 inches thick. The subsurface layer is very dark gray silt loam about 4 inches thick. The subsoil is dark grayish brown clay about 9 inches thick. The underlying material is olive gray silty clay that contains salt crystals and that is mottled with brown in the lower part.

Permeability is very slow, and the available water capacity is moderate. The organic-matter content is high, and fertility is medium. These soils have a deep water table.

Nahon soils are fairly well suited to farming, but they are not suited to trees. Nearly all areas of these soils are used for crops. The limitations for most nonfarm uses are moderate and severe.

Representative profile of Nahon silt loam, in a cultivated field, 180 feet north and 2,520 feet west of the southwest corner of sec. 21, T. 144 N., R. 52 W.

Ap—0 to 8 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) when dry; weak medium granular structure; slightly hard, friable, slightly sticky and slightly plastic; common roots and pores; neutral; abrupt smooth boundary.

A2—8 to 12 inches, very dark gray (10YR 3/1) silt loam, gray (10YR 5/1) when dry; weak medium platy structure; slightly hard, very friable, slightly sticky and slightly plastic; common roots and many pores; neutral; abrupt wavy boundary.

B2t—12 to 21 inches, dark grayish brown (2.5Y 4/2) clay, grayish brown (2.5Y 5/2) when dry; strong coarse columnar structure parting to strong fine and medium blocky; very hard, very firm, very sticky and very plastic; few roots and pores in upper part; continuous clay films on prisms and blocks; mildly alkaline; gradual wavy boundary.

C1—21 to 32 inches, olive gray (5Y 5/2) silty clay, light olive gray (5Y 6/2) when dry; weak coarse prismatic structure parting to weak medium blocky; hard, firm, very sticky and very plastic; few salt crystals; strongly effervescent; moderately alkaline; gradual wavy boundary.

C2—32 to 48 inches, olive gray (5Y 4/2) silty clay, light olive gray (5Y 6/2) when dry; weak fine blocky

Figure 11.—**A typical area of Marsh. The vegetation is mainly bulrushes and cattails.**

structure; very hard, very firm, very sticky and very plastic; common salt crystals; slightly effervescent; moderately alkaline; gradual wavy boundary.

C3g—48 to 60 inches, olive gray (5Y 5/2) silty clay, light gray (5Y 6/1) when dry; common medium distinct brown (10YR 4/3) mottles; weak medium blocky structure; very hard, very firm, very sticky and very plastic; many salt crystals; strongly effervescent; moderately alkaline.

The solum ranges from 19 to 36 inches in thickness. The A1 horizon ranges from 7 to 10 inches in thickness. It is black or very dark gray silt loam or silty clay loam. The A2 horizon ranges from 2 to 6 inches in thickness. It is very dark gray to gray loam or silt loam. The B2 horizon ranges from 9 to 18 inches in thickness. It is very dark gray to olive gray clay or silty clay. The B horizon is mildly alkaline or moderately alkaline. The C horizon is moderately alkaline or strongly alkaline and contains gypsum crystals in some places. Mottles are distinct or prominent in the lower part of this horizon.

Nahon soils are near the Fargo, Overly, and Tiffany soils. They contain less clay in the A horizon than Fargo soils, but they have a claypan. They have a claypan, which is lacking in Overly soils. They contain more clay and less sand and are better drained than Tiffany soils.

Na—Nahon silt loam. This nearly level soil is on the delta and between the beaches. It has the profile described as representative of the series. The surface layer is silt loam in most areas, but it is silty clay loam in a few areas. Slopes are 0 to 1 percent.

Included with this soil in mapping are gumbo spots that have poor tilth. A few small wet areas are indicated by a spot symbol on the soil map.

This soil has a claypan that restricts the penetration of roots, air, and moisture. Soil blowing is a moderate hazard. Runoff is slow.

Nearly all areas of this soil are used for crops. This soil is fairly well suited to farming, but it is not suited to trees. Improving permeability, selecting crops, conserving moisture, and controlling soil blowing are the main concerns of management. Capability unit IIIs–5P; windbreak suitability group 9.

Nutley Series

The Nutley series consists of deep, well drained, nearly level to moderately steep soils. These soils are on beaches, in slightly elevated areas adjacent to streams on glacial lake plains, and on the breaks to drainageways and streams. They formed in fine textured glacial lacustrine deposits.

In a representative profile (fig. 12) the surface layer is black silty clay about 9 inches thick. The subsoil is dark grayish brown silty clay about 15 inches thick. The underlying material is silty clay mottled with brown. The upper part of this material is grayish brown, and the lower part is olive colored.

Permeability is slow, and the available water capacity is high. The organic-matter content is moderate, and fertility is medium. These soils have a deep water table.

In most areas Nutley soils are well suited to farming and fairly well suited to trees. Most areas are used for crops, but some are in grass and native woodland. The limitations for most nonfarm uses are severe.

Representative profile of Nutley silty clay, 1 to 3 percent slopes, in a cultivated field, 192 feet north and 2,310 feet west of the southeast corner of sec. 2, T. 146 N., R. 53 W.

Figure 12.—**Profile of Nutley silty clay. Dark-colored tongues extend through the light-colored subsoil.**

Ap—0 to 7 inches, black (10YR 2/1) silty clay, very dark gray (10YR 3/1) when dry; moderate fine granular structure; hard, firm, very sticky and very plastic; many roots and common pores; mildly alkaline; abrupt smooth boundary.

A12—7 to 9 inches, black (10YR 2/1) silty clay, very dark gray (10YR 3/1) when dry; moderate medium blocky structure; hard, firm, very sticky and very plastic; common roots and many pores; mildly alkaline; clear irregular boundary.

B2—9 to 16 inches, dark grayish brown (2.5Y 4/2) silty clay, light brownish gray (2.5Y 6/2) when dry; few tongues of black (10YR 2/1) extend through this horizon; moderate medium prismatic structure parting to moderate fine blocky; hard, firm, very sticky and very plastic; common roots and many pores; slightly effervescent; mildly alkaline; gradual irregular boundary.

B3—16 to 24 inches, dark grayish brown (2.5Y 4/2) silty clay, light brownish gray (2.5Y 6/2) when dry; few tongues of black (10YR 2/1) extend into this horizon; moderate medium prismatic structure parting to moderate fine blocky; hard, firm, very sticky and very plastic; common roots and many pores; strongly effervescent; mildly alkaline; gradual wavy boundary.

C1—24 to 34 inches, grayish brown (2.5Y 5/2) silty clay, light gray (2.5Y 7/2) when dry; few medium faint brown (10YR 4/3) mottles; weak medium blocky structure; hard, firm, very sticky and very plastic; common roots and many pores; strongly effervescent; mildly alkaline; gradual wavy boundary.

C2—34 to 60 inches, olive (5Y 5/3) silty clay, pale yellow (5Y 7/3) when dry; common medium distinct brown (10YR 4/3) mottles; massive; hard, firm, very sticky and very plastic; strongly effervescent; mildly alkaline.

The solum ranges from 14 to 26 inches in thickness. The A horizon ranges from 6 to 16 inches in thickness. It is

black or very dark gray clay or silty clay. The B horizon ranges from 10 to 18 inches in thickness. It is dark grayish brown to olive clay or silty clay. The C horizon is dark grayish brown to olive clay or silty clay. Mottles range from few to many and faint to prominent. Gypsum crystals are in the C horizon in some places. The C horizon is commonly laminated below a depth of 36 inches.

In Traill County Nutley silty clay, 15 to 25 percent slopes, has a surface layer that is lighter colored than is defined for the Nutley series. This difference does not alter the usefulness or behavior of the soil.

Nutley soils formed in material similar to that in which the Dovray, Fargo, and Hegne soils formed. They have a thinner solum and are better drained than Dovray soils. They are better drained than Fargo soils. Unlike Hegne soils, Nutley soils lack a layer that has an accumulation of lime within 16 inches of the surface.

NuA—Nutley silty clay, 1 to 3 percent slopes. This nearly level soil is on low, slightly convex beaches and in slightly elevated areas adjacent to streams on glacial lake plains. It has the profile described as representative of the series. The surface layer is silty clay in most places, but it is clay in a few places.

Included with this soil in mapping are some areas of Fargo silty clay, which makes up not more than 15 percent of this mapping unit. The Fargo soil is on plane and slightly concave side slopes. Small areas that are steep and have short slopes are indicated by a spot symbol on the soil map.

Runoff is medium. The hazard of soil blowing is moderate.

Nearly all areas of this soil are used for crops. This soil is well suited to farming and fairly well suited to trees. It is difficult to till. Maintaining and improving tilth, organic-matter content, and fertility and controlling soil blowing are the main concerns of management. Capability unit IIs–4; windbreak suitability group 4.

NuB—Nutley silty clay, 3 to 6 percent slopes. This gently sloping soil is on beaches and the breaks to drainageways and streams. It has a profile similar to the one described as representative of the series, but the surface layer is not so thick. The surface layer is silty clay in most places, but it is clay in a few places.

Included with this soil in mapping are some areas of Fargo silty clay, which makes up not more than 15 percent of this mapping unit. The Fargo soil is on plane and slightly concave lower side slopes of beaches and breaks. Small areas that are steep and have short slopes are indicated by a spot symbol on the soil map.

Runoff is medium. The hazards of soil blowing and water erosion are moderate.

Most areas of this soil are used for crops, but a few areas are in grass that is cut for hay or used for pasture. This soil is well suited to farming and fairly well suited to trees. It is difficult to till. Controlling water erosion and soil blowing and maintaining and improving organic-matter content and tilth are the main concerns of management. Capability unit IIe–4; windbreak suitability group 4.

NuC—Nutley silty clay, 6 to 9 percent slopes. This sloping soil is on beaches and breaks to drainageways and streams. It has a profile similar to the one described as representative of the series, but the surface layer is not so thick. The surface layer is silty clay in most places, but it is clay in a few places.

Included with this soil in mapping are small areas of soil that is calcareous at the surface. Small areas that are steep and have short slopes are indicated by a spot symbol on the soil map.

Runoff is rapid. The hazard of water erosion is severe, and the hazard of soil blowing is moderate.

Most areas of this soil are used for crops, but some areas are in grass and native woodland that are used for wildlife habitat, cut for hay, or used for pasture. This soil is fairly well suited to farming and to trees. It is difficult to till. Controlling water erosion and maintaining and improving organic-matter content, tilth, and fertility are the main concerns of management. Capability unit IIIe–4; windbreak suitability group 4.

NuD—Nutley silty clay, 9 to 15 percent slopes. This strongly sloping soil is on breaks of drainageways and streams. It has a profile similar to the one described as representative of the series, but the surface layer is not so thick.

Included with this soil in mapping are small areas of soil that is calcareous at the surface. A few small areas that are steep and have short slopes are indicated by a spot symbol on the soil map.

Runoff is rapid. The hazard of water erosion is very severe, and the hazard of soil blowing is moderate.

Most areas of this soil are used for crops, but some areas are in grass and native woodland that are used for wildlife habitat, cut for hay, or used for pasture. This soil is poorly suited to farming but fairly well suited to trees. It is difficult to till. Controlling water erosion, maintaining and improving organic-matter content, fertility, and tilth in areas used for crops, and maintaining high-quality vegetation in areas used for hay and pasture are the main concerns of management. Capability unit IVe–4; windbreak suitability group 4.

NuE—Nutley silty clay, 15 to 25 percent slopes. This moderately steep soil is on breaks to drainageways and streams and in areas of rapid entrenchment. It has a profile similar to the one described as representative of the series, but the surface layer is lighter colored. A few small areas that are steep and have short slopes are indicated by a spot symbol on the soil map.

Runoff is rapid. The hazard of water erosion is very severe.

Most areas of this soil are in grass, but some areas are in native woodland. This soil is used for wildlife habitat or pasture. It is generally not suited to cultivated crops nor to the trees that are used in windbreaks. Maintaining high-quality vegetation for pasture and controlling water erosion are the main concerns of management. Capability unit VIe–4; windbreak suitability group 10.

Ojata Series

The Ojata series consists of deep, nearly level, poorly drained, strongly saline soils. These soils are in shallow depressions and swales on the delta, between the beaches and on the glacial lake plain. They formed in medium textured and moderately fine textured glacial melt–water deposits.

In a representative profile the surface layer is black silty clay loam about 7 inches thick. The underlying material, to a depth of 24 inches, is dark gray and gray silty clay loam that has an accumulation of lime and other salts. Below this is mottled olive gray

silty clay loam, olive brown silt loam, and gray silt loam.

Permeability is slow, and the available water capacity is moderate. The organic-matter content is high, and fertility is low. These soils have a high water table 1 to 3 feet below the surface. They are strongly saline.

Ojata soils are generally not suited to farming nor to trees. Nearly all areas of these soils are in grass, but a few areas are used for crops. The limitations for most nonfarm uses are severe.

Representative profile of Ojata silty clay loam, in grass, 564 feet west and 225 feet south of the northeast corner of sec. 2, T. 146 N., R. 51 W.

A1—0 to 7 inches, black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) when dry; weak medium granular structure; slightly hard, friable, sticky and plastic; common roots and pores; common fine salt crystals; strongly effervescent; moderately alkaline; clear wavy boundary.

C1casa—7 to 18 inches, dark gray (5Y 4/1) silty clay loam, gray (5Y 6/1) when dry; weak coarse prismatic structure; slightly hard, friable, sticky and plastic; few roots and common pores; common fine salt crystals; violently effervescent; moderately alkaline; gradual wavy boundary.

C2gca—18 to 24 inches, gray (5Y 6/1) silty clay loam, light gray (5Y 7/1) when dry; weak coarse prismatic structure; hard, friable, sticky and plastic; few roots and common pores; violently effervescent; moderately alkaline; gradual smooth boundary.

C3g—24 to 30 inches, olive gray (5Y 5/2) silty clay loam, light gray (5Y 7/2) when dry; many medium distinct gray (5Y 6/1) mottles; weak coarse prismatic structure; few roots and common pores; common fine salt roots and pores; strongly effervescent; moderately alkaline; gradual smooth boundary.

C4g—30 to 44 inches, olive brown (2.5Y 4/4) silt loam, pale yellow (2.5Y 7/4) when dry; few fine distinct yellowish red mottles and many coarse distinct gray (5Y 5/1) mottles; weak medium platy structure; hard, friable, sticky and plastic; few roots and pores; slightly effervescent; moderately alkaline; gradual wavy boundary.

C5g—44 to 60 inches, gray (5Y 5/1) silt loam, light gray (5Y 7/1) when dry; many coarse prominent reddish brown (5YR 4/4) mottles; massive; hard, friable, sticky and plastic; slightly effervescent; moderately alkaline.

The A horizon ranges from 6 to 16 inches in thickness. It is black or very dark gray silt loam or silty clay loam. The Cca horizon is olive to dark gray silt loam or silty clay loam. The Cg horizon is dark gray to pale olive and has few to many, faint to prominent mottles. This horizon commonly is silty clay loam or silt loam, but below a depth of 40 inches in some places, it ranges from loam to silty clay. Gypsum crystals are common in the C horizon in some places.

Ojata soils formed in material similar to that in which the Bearden, Colvin, and Perella soils formed. Ojata soils are more poorly drained than Bearden soils. They contain more soluble salts of magnesium and sodium than Bearden and Colvin soils. Unlike Perella soils, Ojata soils have a layer where lime has accumulated within 16 inches of the surface.

Oa—Ojata silty clay loam. This nearly level soil is in in shallow depressions and swales on the delta, between the beaches, and on the glacial lake plain. It has the profile described as representative of the series. The surface layer is silty clay loam in most places, but it is silt loam in a few places. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of either Vallers silty clay loam or Colvin silty clay loam, which makes up not more than 15 percent of this mapping unit. These soils are in swales and depressions.

This soil has a high content of soluble salts that affect plant growth. Runoff is very slow. In most areas water ponds in spring during periods when rainfall is heavy and snow melts rapidly. A high water table is near the surface in spring and during periods of heavy rainfall.

Nearly all areas of this soil are in grass that is used for wildlife habitat, cut for hay, or used for pasture. A few areas are used for crops. This soil is generally not suited to farming nor to trees. Controlling salinity, removing excess water, and maintaining high-quality vegetation for hay and pasture are the main concerns of management. Capability unit VIs–6; windbreak suitability group 10.

Overly Series

The Overly series consists of deep, nearly level and gently sloping, moderately well drained soils. These soils are on low beaches, on breaks to drainageways and streams, and in slightly elevated areas adjacent to breaks on the delta, between the beaches, and on the glacial lake plain. They formed in moderately fine textured glacial lacustrine deposits.

In a representative profile the surface layer is black silty clay loam about 12 inches thick. The subsoil is very dark grayish brown silty clay loam about 10 inches thick. The underlying material is silty clay loam. The upper part is light yellowish brown and has an accumulation of lime. The lower part is light olive brown and mottled with gray.

Permeability is moderately slow, and the available water capacity is high. The organic-matter content and fertility are high. These soils have a deep water table.

Overly soils are well suited to farming and to trees. Nearly all areas of these soils are used for crops, but a few areas are in grass. The limitations for nonfarm uses range from slight to severe.

Representative profile of Overly silty clay loam, in a cultivated field, 385 feet north and 125 feet west of the southeast corner of sec. 30, T. 147 N., R. 53 W.

Ap—0 to 7 inches, black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) when dry; moderate fine granular structure; slightly hard, friable, sticky and plastic; many roots and pores; slightly acid; abrupt smooth boundary.

A12—7 to 12 inches, black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) when dry; weak medium and coarse blocky structure parting to weak fine granular; slightly hard, friable, sticky and plastic; many roots and pores; slightly acid; gradual wavy boundary.

B2—12 to 22 inches, very dark grayish brown (10YR 3/2) silty clay loam, grayish brown (10YR 5/2) when dry; moderate medium prismatic structure parting to moderate medium blocky; hard, firm, sticky and plastic; common roots and pores; slightly acid; gradual wavy boundary.

C1ca—22 to 33 inches, light yellowish brown (2.5Y 6/4) silty clay loam, light gray (2.5Y 7/2) when dry; weak coarse blocky structure; hard, friable, sticky and plastic; few roots and pores; violently effervescent; mildly alkaline; gradual wavy boundary.

C2—33 to 60 inches, light olive brown (2.5Y 5/4) silty clay loam, pale yellow (2.5Y 7/4) when dry; common medium distinct gray (5Y 5/1) mottles; mas-

sive; hard, friable, sticky and plastic; slightly effervescent; mildly alkaline.

The solum ranges from 16 to 32 inches in thickness. The A horizon ranges from 8 to 18 inches in thickness and is black or very dark gray. It is silty clay loam in most places, but it is silt loam in some places. This horizon is slightly acid or neutral. The B horizon ranges from 8 to 14 inches in thickness and is very dark gray to dark grayish brown. It is silty clay loam in most places, but it is silt loam in some places. This horizon is slightly acid or neutral. The lower part of the B horizon is calcareous in some places. The C horizon commonly is silty clay loam or silt loam, but below a depth of 40 inches in a few places it is very fine sandy loam, silty clay, or clay. This horizon is mildly alkaline or moderately alkaline.

Overly soils formed in material similar to that in which the Bearden, Great Bend, and Perella soils formed. Overly soils are better drained than Bearden soils, but they lack a layer where lime has accumulated within 16 inches of the surface. They are darker colored to a greater depth than Great Bend soils. They are better drained than Perella soils.

Or—Overly silty clay loam. This nearly level soil is in slightly elevated areas adjacent to breaks and broad areas on the delta and glacial lake plain. It has the profile described as representative of the series. The surface layer is silty clay loam in most places, but it is silt loam in a few places. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Bearden silty clay loam, which makes up about 15 percent of this mapping unit, and Beotia silty clay loam, which makes up not more than 10 percent. The Bearden soil is on slightly convex slopes, and the Beotia soil is on plane and slightly convex slopes. Small wet areas, a few small areas that are steep and have short slopes, small saline areas, and a few small areas of gumbo spots are indicated by spot symbols on the soil map.

Soil blowing is a slight hazard. Runoff is slow.

Nearly all areas of this soil are used for crops, but a few areas are in grass that is cut for hay or used for pasture. This soil is well suited to farming and to trees. Conserving moisture and maintaining fertility and tilth are the main concerns of management. Capability unit IIc–6; windbreak suitability group 1.

Os—Overly-Fargo complex. The soils of this complex are nearly level and are in broad areas on the glacial lake plain. The Overly soil has a thicker deposit of silty material over clay and is better drained than the Fargo soil. This complex is about 55 percent Overly silty clay loam and about 30 percent Fargo silty clay. Slopes are 0 to 1 percent.

The Overly soil has a profile similar to the one described as representative of the series, but the substratum is clay ranging from 40 to 60 inches below the surface. It has a surface layer of silty clay loam in most areas, but it is silt loam in some areas.

Included with this complex in mapping are some areas of Bearden silty clay loam that has a substratum of clay at a depth of 24 to 60 inches, and which makes up not more than 10 percent of this mapping unit, and Galchutt silty clay loam, which makes up not more than 5 percent. The Bearden soil is on slightly convex slopes, and the Galchutt soil is in shallow swales and depressions. Also included in mapping are areas of Overly soils that have a substratum of clay at a depth of 24 to 40 inches. A few small wet areas and a few small areas that are steep and have short slopes are indicated by spot symbols on the soil map.

Runoff is slow on the Overly soil and very slow on the Fargo soil. Permeability in the Overly soil is moderately slow above the clay substratum and slow in it. The hazard of soil blowing is slight on the Overly soil and moderate on the Fargo soil. Excess water is a problem on the Fargo soil in places during the periods when rainfall is heavy and snow melts rapidly.

Nearly all areas of this complex are used for crops. This complex is well suited to farming and to trees. The Overly soil is more easily tilled than the Fargo soil. Conserving moisture and maintaining fertility and tilth are the main concerns of management. Capability unit IIc–6; windbreak suitability group 1.

OvB—Overly-Great Bend silty clay loams, 3 to 6 percent slopes. The soils of this complex are gently sloping and are on low beaches, breaks to drainageways and to streams on the delta, between the beaches, and on the glacial lake plain. The Overly soil is on plane and slightly concave lower side slopes, and the Great Bend soil is on convex side slopes. This complex is at least 54 percent Overly silty clay loam and about 32 percent Great Bend silty clay loam. In a few places these soils have a surface layer of silt loam instead of silty clay loam.

Included with this complex in mapping are some areas of Beotia silty clay loam, which makes up not more than 14 percent of this mapping unit. This soil is on plane and slightly convex side slopes. A few small areas that are steep and have short slopes are indicated by a spot symbol on the soil map.

Runoff is slow on the Overly soil and medium on the Great Bend soil. Water erosion is a moderate hazard, and soil blowing is a slight hazard.

Nearly all areas of this complex are used for crops, but a few areas are in grass and native woodland that are used for wildlife habitat, cut for hay, and used for pasture. This complex is well suited to farming and to trees. Controlling water erosion and maintaining and improving fertility and tilth are the main concerns of management. Capability unit IIe–6; Overly part in windbreak suitability group 1, Great Bend part in windbreak suitability group 3.

Perella Series

The Perella series consists of deep, poorly drained, nearly level soils. These soils are in shallow depressions and swales on the delta, between the beaches, and on the glacial lake plain. They formed in medium textured and moderately fine textured glacial lacustrine deposits.

In a representative profile the surface layer is black silty clay loam about 11 inches thick. The subsoil is very dark gray silty clay loam about 11 inches thick. The underlying material is silty clay loam. The upper part is dark grayish brown and mottled with yellowish brown, the middle part is pale olive and mottled with brown, and the lower part is light olive gray and mottled with brown.

Permeability is moderately slow, and the available water capacity is high. The organic-matter content and fertility are high. These soils have a high water table 1 to 3 feet below the surface.

Perella soils are well suited to farming and to trees if excess water is removed. Most areas of these soils

are used for crops, but a few areas are in grass. The limitations for most nonfarm uses are severe.

Representative profile of Perella silty clay loam, in an area of Bearden-Perella silty clay loams, in a cultivated field, 111 feet west and 1,548 feet south of the northeast corner of sec. 4, T. 148 N., R. 50 W.

Ap—0 to 7 inches, black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) when dry; weak fine granular structure; hard, friable, sticky and plastic; few roots and many pores; neutral; abrupt smooth boundary.

A12—7 to 11 inches, black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) when dry; weak medium blocky structure; hard, friable, sticky and plastic; few roots and many pores; neutral; clear smooth boundary.

B2g—11 to 22 inches, very dark gray (2.5Y 3/1) silty clay loam, dark gray (2.5Y 4/1) when dry; weak medium prismatic structure parting to moderate fine blocky; hard, friable, sticky and plastic; few roots and many pores; neutral; gradual wavy boundary.

C1g—22 to 35 inches, dark grayish brown (2.5Y 4/2) silty clay loam, grayish brown (2.5Y 5/2) when dry; few medium distinct yellowish brown (10YR 5/4) mottles; weak medium prismatic structure parting to weak fine blocky; hard, friable, sticky and plastic; few roots and common pores; neutral; clear wavy boundary.

C2—35 to 44 inches, pale olive (5Y 6/3) silty clay loam, pale yellow (5Y 7/3) when dry; many medium distinct brown (10YR 4/3) mottles; massive; hard, friable, sticky and plastic; strongly effervescent; neutral; gradual wavy boundary.

C3g—44 to 60 inches, light olive gray (5Y 6/2) silty clay loam, light gray (5Y 7/2) when dry; many coarse prominent brown (10YR 4/3) mottles; massive; hard, friable, sticky and plastic; strongly effervescent; neutral.

The soil is neutral or mildly alkaline. The solum ranges from 18 to 36 inches in thickness. The depth to carbonates ranges from 18 to 36 inches. The A horizon ranges from 10 to 18 inches in thickness. It is black or very dark gray silt loam or silty clay loam. The B horizon ranges from 8 to 18 inches in thickness. It is black to olive gray silt loam or silty clay loam. The C horizon is commonly silt loam or silty clay loam, but below a depth of 40 inches in a few places, it ranges from very fine sandy loam to clay.

Perella soils formed in material similar to that in which the Bearden, Colvin, and Overly soils formed. They are more poorly drained than Bearden and Overly soils. Unlike Bearden and Colvin soils, they lack a layer where lime has accumulated within 16 inches of the surface.

Pe—Perella silt loam. This nearly level soil is in shallow depressions and swales on the delta, between the beaches, and on the glacial lake plain. It has a profile similar to the one described as representative of the series, but it is silt loam throughout the profile. The surface layer is silty clay loam instead of silt loam in some areas. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Bearden silt loam, which makes up not more than 15 percent of this mapping unit, and Colvin silt loam, which makes up not more than 5 percent. The Bearden soil is on the rims of shallow depressions and the edges of swales, and the Colvin soil is on the edges of swales and depressions. Also included in mapping are a few areas of soils that are very poorly drained.

Runoff is very slow. Water ponds in spring and during periods of heavy rainfall. A high water table is near the surface in spring and during periods of heavy rainfall.

Most areas of this soil are used for crops, but some areas are in grass that is used for wildlife habitat, cut for hay, or used for pasture. This soil is well suited to farming and to trees if excess water is removed. Removing excess water and maintaining fertility are the main concerns of management. Capability unit IIw–6; windbreak suitability group 2.

Playmoor Series

The Playmoor series consists of deep, poorly drained, nearly level, saline soils. These soils are on low flood plains along streams. They formed in moderately fine textured alluvium.

In a representative profile the surface layer is silty clay loam, about 26 inches thick, that contains many or common fine segregations of salts. The upper part is black, and the lower part is very dark gray. The underlying material, to a depth of about 32 inches, is dark silty clay loam that contains few fine segregations of salts. Below this is a buried former surface layer, about 13 inches thick, that is very dark gray silty clay loam mottled with brown. It is underlain by dark gray silty clay loam mottled with brown.

Permeability is moderately slow, and the available water capacity is moderate. The organic-matter content is high, and fertility is medium. These soils are subject to flooding by streams. They have a high water table 1 to 3 feet below the surface.

Playmoor soils are poorly suited to farming and not suited to trees. Most areas of these soils are in grass, but a few areas are used for crops. The limitations for most nonfarm uses are severe.

Representative profile of Playmoor silty clay loam, in grass, 2,354 feet north and 180 feet west of the southeast corner of sec. 17, T. 145 N., R. 51 W.

A11—0 to 9 inches, black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) when dry; weak medium granular structure; slightly hard, friable, sticky and plastic; many roots and few pores; many fine salt segregations; slightly effervescent; mildly alkaline; gradual wavy boundary.

A12—9 to 26 inches, very dark gray (10YR 3/1) silty clay loam, dark gray (10YR 4/1) when dry; weak coarse prismatic structure parting to weak medium granular; slightly hard, friable, sticky and plastic; many roots and common pores; common fine segregations of salts; slightly effervescent; moderately alkaline; gradual wavy boundary.

C1gsa—26 to 32 inches, dark gray (5Y 4/1) silty clay loam, gray (5Y 5/1) when dry; weak coarse prismatic structure parting to weak medium granular; hard, friable, sticky and plastic; few roots and common pores; few fine salt segregations; strongly effervescent; moderately alkaline; clear smooth boundary.

A1b—32 to 45 inches, very dark gray (10YR 3/1) silty clay loam, dark gray (10YR 4/1) when dry; few fine distinct brown mottles; weak fine blocky structure; hard, friable, sticky and plastic; few roots and pores; slightly effervescent; moderately alkaline; gradual smooth boundary.

C2g—45 to 60 inches, dark gray (5Y 4/1) silty clay loam, gray (5Y 6/1) when dry; common fine distinct brown (10YR 4/3) mottles; massive; hard, friable, sticky and plastic; slightly effervescent; moderately alkaline.

The A horizon ranges from 24 to 40 inches in thickness. It is mildly alkaline or moderately alkaline. It is silt loam or silty clay loam and contains few to many segregations of salt. Buried A horizons are common. The C horizon commonly is silt loam or silty clay loam, but below a depth of 40 inches, it has strata of sand, silt, or clay in some

places. This horizon contains few to many segregations of salts.

Playmoor soils formed in material similar to that in which the Fairdale, Lamoure, and La Prairie soils formed. They have a darker colored A horizon than Fairdale soils. They contain moderate amounts of the salts of sodium and magnesium, which are lacking in Lamoure soils. They are more poorly drained than La Prairie soils.

Pr—Playmoor silty clay loam. This nearly level soil is on low flood plains along streams. It has the profile described as representative of the series. The surface layer is silty clay loam in most places, but it is silt loam in a few places. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Lamoure silty clay loam, which makes up not more than 15 percent of this mapping unit, and La Prairie silt loam, which makes up not more than 7 percent. The Lamoure soil is on low flood plains, and the La Prairie soil is on low terraces and high bottom lands.

Runoff is slow. This soil is subject to flooding in spring during periods when rainfall is heavy and snow melts rapidly. This soil contains a moderate amount of soluble salts that affect plant growth.

Most areas of this soil are in grass that is used for wildlife habitat, cut for hay, or used for pasture. A few areas are used for salt-tolerant crops. This soil is poorly suited to farming and is not suited to trees. Controlling salinity, selecting salt-tolerant crops, and removing excess water are the main concerns of management. Capability unit IVw–4L; windbreak suitability group 10.

Renshaw Series

The Renshaw series consists of nearly level, somewhat excessively drained soils that are shallow to coarse sand and gravel. These soils are on beaches and on the glacial till plain. They formed in a thin layer of medium textured glacial melt-water deposits underlain by coarse sand and gravel.

In a representative profile the surface layer is black loam about 12 inches thick. The subsoil is dark brown loam about 6 inches thick. The underlying material is coarse sand and gravel. The upper part is brown, the middle part is light olive brown, and the lower part is olive.

Permeability is moderately rapid in the surface layer and subsoil and very rapid in the underlying material. The available water capacity is low. The organic-matter content is high, and fertility is medium. These soils have a deep water table.

Renshaw soils are fairly well suited to farming and poorly suited to trees. Most areas of these soils are used for crops, but a few areas are in grass. A few areas have potential as a source of sand and gravel. The limitations for nonfarm uses range from slight to severe.

Representative profile of Renshaw loam, 1 to 3 percent slopes, in a cultivated field, 78 feet west and 213 feet south of the northeast corner of sec. 19, T. 144 N., R. 53 W.

Ap—0 to 6 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) when dry; weak medium granular structure; slightly hard, very friable, slightly sticky and slightly plastic; common roots and pores; neutral; abrupt smooth boundary.

A12—6 to 12 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) when dry; weak coarse prismatic structure parting to weak medium granular; slightly hard, very friable, slightly sticky and slightly plastic; common roots and pores; neutral; clear wavy boundary.

B2—12 to 18 inches, dark brown (10YR 3/3) loam, brown (10YR 4/3) when dry; weak coarse prismatic structure parting to weak medium subangular blocky; slightly hard, very friable, slightly sticky and slightly plastic; few roots and common pores; slightly effervescent; mildly alkaline; gradual wavy boundary.

IIC1—18 to 25 inches, brown (10YR 4/3) coarse sand and gravel, brown (10YR 5/3) when dry; single grained; loose, nonsticky and nonplastic; slightly effervescent; mildly alkaline; gradual wavy boundary.

IIC2—25 to 50 inches, light olive brown (2.5Y 5/4) coarse sand and gravel, light yellowish brown (10YR 6/4) when dry; single grained; loose, nonsticky and nonplastic; slightly effervescent; moderately alkaline; gradual wavy boundary.

IIC3—50 to 60 inches, olive (5Y 5/4) coarse sand and gravel, pale olive (5Y 6/4) when dry; single grained; loose, nonsticky and nonplastic; slightly effervescent; mildly alkaline.

The solum ranges from 10 to 20 inches in thickness. The A horizon ranges from 6 to 12 inches in thickness and is black or very dark gray. The B horizon ranges from 4 to 8 inches in thickness. It is very dark gray to brown loam that has increasing amounts of sand as depth increases. The C horizon has a weakly expressed horizon where lime has accumulated in the form of crusts on pebbles in some places. It is mildly alkaline or moderately alkaline.

Renshaw soils are near the Emrick, Lankin, and Sioux soils. They have a IIC horizon of coarse sand and gravel that is lacking in Emrick and Lankin soils. They have a B horizon that is lacking in Sioux soils.

ReA—Renshaw loam, 1 to 3 percent slopes. This nearly level soil is on beaches, between the beaches, and on the glacial till plain. It has the profile described as representative of the series.

Included with this soil in mapping are some areas of Divide loam, which makes up not more than 15 percent of this mapping unit, and Lankin loam, which makes up not more than 10 percent. The Divide soil is on plane and slightly concave lower side slopes, and the Lankin soil is on plane and slightly concave side slopes. Also included in mapping are small areas where coarse sand and gravel is below a depth of 20 inches and slopes are 3 to 6 percent. A few small wet areas and a few small areas that are steep and have short slopes are indicated by spot symbols on the soil map.

The available water capacity is low. Runoff is slow. Soil blowing is a slight hazard.

Most areas of this soil are used for crops, but a few small areas are in grass that is cut for hay or used for pasture. A few areas have potential as a source of sand and gravel. This soil is fairly well suited to farming but poorly suited to trees. Conserving moisture and improving fertility are the main concerns of management. Capability unit IIIs–5; windbreak suitability group 6.

Rockwell Series

The Rockwell series consists of deep, nearly level, poorly drained soils. These soils are in broad areas between the beaches and on the delta. They formed in moderately coarse textured glacial melt-water deposits and the underlying moderately fine textured water-worked glacial till.

In a representative profile the surface layer is very

dark gray fine sandy loam about 7 inches thick. The underlying material, to a depth of 16 inches, is gray fine sandy loam that has an accumulation of lime and that is mottled with brown. Below this is 10 inches of light brownish gray fine sandy loam mottled with brown. The next layer is gray clay loam that has an accumulation of lime and that is mottled with brown in the upper part and light olive brown and brown in the lower part.

Permeability is moderate in the upper part and moderately slow in the lower underlying material. The available water capacity is high. The organic-matter content is high, and fertility is medium. These soils have a seasonal high water table 1 to 3 feet below the surface.

Rockwell soils are fairly well suited to farming, and they are well suited to trees if excess water is removed. Most areas of these soils are used for crops, but a few areas are in grass. The limitations for many nonfarm uses are severe.

Representative profile of Rockwell fine sandy loam, in a cultivated field. 1,520 feet west and 276 feet north of the southeast corner of sec. 30, T. 148 N., R. 50 W.

Ap—0 to 7 inches, very dark gray (10YR 3/1) fine sandy loam, dark gray (10YR 4/1) when dry; weak medium granular structure; soft, very friable, slightly sticky and slightly plastic; few roots and common pores; strongly effervescent; mildly alkaline; abrupt smooth boundary.

C1cag—7 to 16 inches, gray (5Y 5/1) fine sandy loam, light gray (5Y 6/1) when dry; few fine distinct brown mottles; weak coarse prismatic structure parting to weak medium subangular blocky; slightly hard, very friable, slightly sticky and slightly plastic; few roots and common pores; violently effervescent; mildly alkaline; clear irregular boundary.

C2g—16 to 26 inches, light brownish gray (2.5Y 6/2) fine sandy loam, light gray (2.5Y 7/2) when dry; few fine distinct brown mottles; weak coarse prismatic structure; soft, very friable, slightly sticky and slightly plastic; few roots and common pores; strongly effervescent; mildly alkaline; clear smooth boundary.

IIC3cag—26 to 32 inches, gray (5Y 5/1) clay loam, light gray (5Y 7/1) when dry; common coarse prominent brown (10YR 4/3) mottles; weak coarse prismatic structure parting to weak fine blocky; hard, firm, sticky and plastic; violently effervescent; mildly alkaline; gradual smooth boundary.

IIC4g—32 to 60 inches, gray (5Y 5/1) clay loam, light gray (5Y 7/1) when dry; many coarse distinct light olive brown mottles and few medium prominent brown (10YR 4/3) mottles; weak medium blocky structure; hard, firm, sticky and plastic; strongly effervescent; mildly alkaline.

The A horizon ranges from 7 to 14 inches in thickness. It is black or very dark gray fine sandy loam or sandy loam. The Cca horizon ranges from 6 to 14 inches in thickness. It is sandy loam or fine sandy loam. The C2 horizon is fine sandy loam to loamy sand. In some places a thin layer of pebbles is on top of the IIC horizon. The depth to the IIC horizon ranges from 20 to 40 inches. This horizon is mildly alkaline or moderately alkaline. It is mainly clay loam and loam water-worked glacial till, but in some places it is silt loam, silt, or silty clay loam lacustrine deposits. It has gypsum crystals in the lower part in some places.

Rockwell soils are near the Averson, Embden, and Wyndmere soils. They have a moderately fine textured IIC horizon, which Averson soils lack. They are more poorly drained than Embden soils and, unlike those soils, have a layer where lime has accumulated within 16 inches of the surface. They are more poorly drained than Wyndmere soils and have a moderately fine textured IIC horizon, which those soils lack.

Ro—Rockwell fine sandy loam. This nearly level soil is in broad areas between the beaches and on the delta. It has the profile described as representative of the series. The surface layer is fine sandy loam in most places, but it is sandy loam in a few places. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Wyndmere fine sandy loam, which makes up not more than 14 percent of this mapping unit, and Arveson fine sandy loam, which makes up not more than 12 percent. The Wyndmere soil is on slightly convex slopes, and the Arveson soil is on plane lower slopes. A few small wet areas and a few small saline areas are indicated by spot symbols on the soil map.

Soil blowing is a moderate hazard. Runoff is very slow. In a few areas, water ponds for short periods in spring during periods when rainfall is heavy and snow melts rapidly. A high water table is near the surface in spring and during periods of heavy rainfall.

Most areas of this soil are used for crops, but a few areas are in grass that is cut for hay or used for pasture. This soil is fairly well suited to farming and, if excess water is removed, is well suited to trees. Controlling soil blowing and removing excess water are the main concerns of management. Capability unit IIIew–3; windbreak suitability group 2.

Ryan Series

The Ryan series consists of deep, nearly level, poorly drained soils that have a claypan. These soils are in areas on the glacial lake plain. They formed in fine textured glacial lacustrine deposits.

In a representative profile the surface layer is firm, black silty clay about 8 inches thick. The subsoil is firm, black silty clay about 7 inches thick. The underlying material is firm silty clay. The upper part is very dark gray and contains common fine salt crystals. The middle part is dark gray and contains a few fine salt crystals. The lower part is olive mottled with yellowish brown.

Permeability is very slow, and the available water capacity is moderate. The organic-matter content is high, and fertility is medium. These soils have a seasonal high water table 1 to 3 feet below the surface. They have a claypan.

Ryan soils are fairly well suited to farming but are not suited to trees. Nearly all areas of these soils are used for crops, but a few areas are in grass. The limitations for many nonfarm uses are severe.

Ryan soils are mapped only in complex with Fargo soils.

Representative profile of Ryan silty clay, in an area of Fargo-Ryan silty clays, in a cultivated field, 610 feet west and 440 feet north of the southeast corner of sec. 12, T. 144 N., R. 52 W.

Ap—0 to 8 inches, black (10YR 2/1) silty clay, dark gray (10YR 4/1) when dry; strong coarse and medium blocky structure; very hard, firm, very sticky and very plastic; few roots and very few pores; upper part of B2t horizon has been mixed with this horizon by plowing; thin vesicular crust on surface; mildly alkaline; abrupt smooth boundary.

B2t—8 to 15 inches, black (10YR 2/1) silty clay, dark gray

(10YR 4/1) when dry; moderate coarse and medium prismatic structure parting to strong very fine blocky; very hard, firm, very sticky and very plastic; few roots and pores; few fine salt crystals; moderately alkaline; clear wavy boundary.

C1g—15 to 23 inches, very dark gray (5Y 3/1) silty clay, gray (5Y 5/1) when dry; moderate very fine blocky structure; very hard, firm, very sticky and very plastic; few roots and pores; common fine salt crystals; slightly effervescent; moderately alkaline; gradual wavy boundary.

C2g—23 to 34 inches, dark gray (5Y 4/1) silty clay, gray (5Y 6/1) when dry; moderate very fine blocky structure; very hard, firm, very sticky and very plastic; few fine salt crystals; strongly effervescent; moderately alkaline; gradual wavy boundary.

C3—34 to 60 inches, olive (5Y 4/3) silty clay, light gray (5Y 7/2) when dry; many medium distinct yellowish brown (10YR 5/6) mottles; massive; very hard, very sticky and very plastic; strongly effervescent; moderately alkaline.

The solum ranges from 9 to 16 inches in thickness. The Ap horizon ranges from 4 to 9 inches in thickness. It is black or very dark gray silty clay or clay. This horizon is mildly alkaline or moderately alkaline. The B horizon ranges from 5 to 7 inches in thickness. It is black or very dark gray silty clay or clay. Few salt crystals are in the lower part of this horizon in most places. The C horizon is dark gray to olive silty clay or clay. It is moderately alkaline or strongly alkaline. Few to many salt crystals are in this horizon in most places.

Ryan soils formed in material similar to that in which the Dovray, Fargo, and Hegne soils formed. They are better drained than Dovray soils. They contain a large amount of magnesium and sodium salts, which Dovray and Fargo soils lack. Unlike Hegne soils, they lack a layer where lime has accumulated within 16 inches of the surface.

Serden Series

The Serden series consists of deep, nearly level to gently sloping, excessively drained soils. These soils are on the delta and between the beaches. They formed in coarse textured eolian deposits. Slopes generally are short and choppy.

In a representative profile the surface layer is black loamy sand about 3 inches thick. Below this is a layer of dark brown sand about 12 inches thick. The underlying material is dark grayish brown sand.

Permeability is rapid, and the available water capacity is low. The organic-matter content and fertility are low. These soils have a deep water table.

Serden soils are generally not suited to farming and are poorly suited to trees. All areas of these soils are in grass. The limitations for many nonfarm uses are severe.

Representative profile of Serden loamy sand, in an area of Serden-Maddock loamy sands, 1 to 6 percent slopes, in grass, 258 feet west and 51 feet north of the southeast corner of sec. 32, T. 146 N., R. 53 W.

A1—0 to 3 inches, black (10YR 2/1) loamy sand, dark gray (10YR 4/1) when dry; weak medium crumb structure; soft, very friable, nonsticky and nonplastic; many roots and pores; slightly acid; clear smooth boundary.

AC—3 to 15 inches, dark brown (10YR 3/3) sand, brown (10YR 5/3) when dry; single grained; loose, nonsticky and nonplastic; common roots and many pores; slightly acid; gradual smooth boundary.

C—15 to 60 inches, dark grayish brown (10YR 4/2) sand, light brownish gray (10YR 6/2) when dry; single grained; loose, nonsticky and nonplastic; neutral.

The A horizon ranges from 1 to 4 inches in thickness. It is black or very dark gray fine sand, loamy sand, or loamy fine sand. This horizon is neutral or slightly acid. The AC horizon is neutral or slightly acid. The C horizon is very dark grayish brown to yellowish brown. Thin, buried A horizons are common in some places.

Serden soils are near the Hecla, Maddock, and Ulen soils. They lack mottles, but Hecla soils have mottles. They have a thinner A horizon than Maddock soils. They lack a calcareous A horizon, but Ulen soils have one.

SmB—Serden-Maddock loamy sands, 1 to 6 percent slopes. The soils of this complex are nearly level to gently sloping and are in areas on the delta and between the beaches. Slopes generally are short and choppy. Generally, Serden soils are on convex side slopes, and Maddock soils are on concave side slopes. This complex is at least 55 percent Serden loamy sand and at least 35 percent Maddock loamy sand.

The Serden soil has the profile described as representative of the series. The Maddock soil has a profile similar to the one described as representative of the series, but the surface layer is loamy sand instead of sandy loam.

Included with this complex in mapping are some areas of Hecla loamy fine sand, which makes up not more than 10 percent of this mapping unit. This soil is on plane and concave side slopes. Also included in mapping are small areas of soils that have a surface layer of fine sand or loamy fine sand.

This complex is highly susceptible to soil blowing. There is little or no runoff on the Serden soil, and runoff is slow on the Maddock soil.

All areas of this complex are in grass that is used for wildlife habitat, cut for hay, or used for pasture. This complex is generally not suited to farming and, in most areas, is poorly suited to trees. Controlling soil blowing and maintaining high-quality vegetation for hay, pasture, and controlling water erosion are the main concerns of management. Capability unit VIe–2; Serden part in windbreak suitability group 7, Maddock part in windbreak suitability group 5.

Sioux Series

The Sioux series consists of excessively drained, nearly level and gently sloping soils that are shallow to coarse sand and gravel. These soils are on beaches between the beaches. They formed in a thin layer of moderately coarse textured glacial melt-water deposits over coarse sand and gravel.

In a representative profile (fig. 13) the surface layer is black gravelly sandy loam about 6 inches thick. The underlying material is stratified coarse sand and gravel. The upper part is brown, and the lower part is grayish brown.

Permeability is moderately rapid in the surface layer and very rapid in the substratum. The available water capacity is very low. The organic-matter content and fertility are low. These soils have a deep water table.

Sioux soils are generally not suited to farming nor to trees. Most areas of these soils are in grass, but a few areas are used for crops. Some areas have potential as a source of sand and gravel. The limitations for nonfarm uses are slight to severe.

Representative profile of Sioux gravelly sandy loam, in an area of Sioux-Arvilla complex, 1 to 6 percent

slopes, in grass, 1,330 feet east and 168 feet north of the southwest corner of sec. 33, T. 148 N., R. 51 W.

A1—0 to 6 inches, black (10YR 2/1) gravelly sandy loam, very dark gray (10YR 3/1) when dry; weak medium subangular blocky structure parting to weak medium granular; soft, very friable, slightly sticky and nonplastic; many roots and few pores; mildly alkaline; abrupt smooth boundary.

IIC1—6 to 30 inches, brown (10YR 5/3) stratified coarse sand and gravel, pale brown (10YR 6/3) when dry; single grained; loose, nonsticky and nonplastic; few roots in the upper 12 inches; strongly effervescent; mildly alkaline; clear smooth boundary.

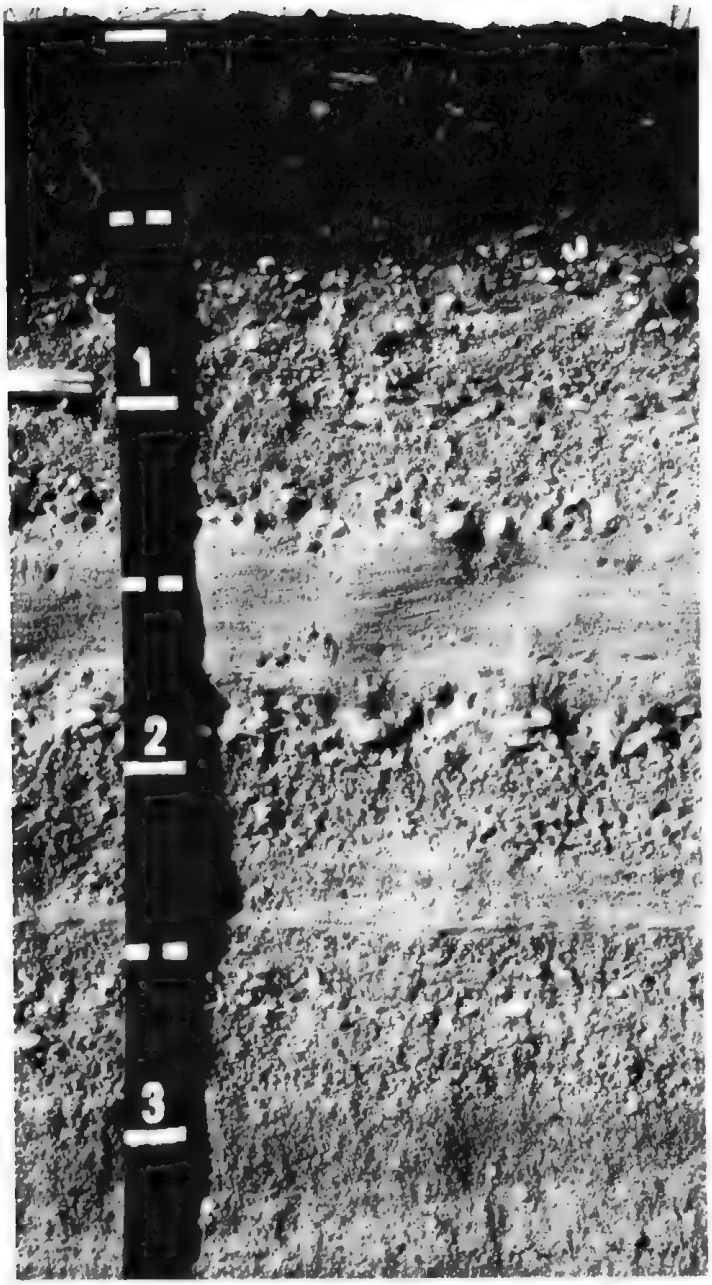

Figure 13.—Profile of Sioux gravelly sandy loam. The dark-colored surface layer overlies stratified coarse sand and gravel.

IIC2—30 to 60 inches, grayish brown (2.5Y 5/2) stratified coarse sand and gravel, light brownish gray (2.5Y 6/2) when dry; single grained; loose, nonsticky and nonplastic; strongly effervescent; mildly alkaline.

The solum ranges from 6 to 10 inches in thickness. The A horizon ranges from 5 to 10 inches in thickness. It is black or very dark gray gravelly loam or gravelly sandy loam. This horizon is neutral or mildly alkaline. Lime crusts coat the bottom of pebbles in the upper part of the IIC horizon in some places.

Sioux soils are near the Arvilla, Divide, and Renshaw soils. They have a thinner solum than Arvilla soils. They lack a B horizon, but Renshaw soils have one. Unlike Divide soils, they lack a layer where lime has accumulated within 16 inches of the surface.

SrB—Sioux-Arvilla complex, 1 to 6 percent slopes. The soils of this complex are nearly level and gently sloping and are on narrow beaches between the beaches. The Sioux soil is on convex upper side slopes, and the Arvilla soil is on convex and plane lower side slopes. This complex is about 53 percent Sioux gravelly sandy loam and about 32 percent Arvilla sandy loam.

The Sioux soil has the profile described as representative of the series. The surface layer of the Sioux soil is gravelly sandy loam in most places, but it is gravelly loam in a few areas.

Included with this soil in mapping are some areas of Hecla sandy loam, which makes up not more than 9 percent of this mapping unit, and Renshaw loam, which makes up not more than 6 percent. The Hecla soil is on plane and slightly concave lower side slopes, and the Renshaw soil is on plane and slightly convex side slopes. Also included in mapping are a few areas of soils that have slopes of 6 to 9 percent.

Soil blowing is a severe hazard. The available water capacity is very low for the Sioux soil and low for the Arvilla soil. Runoff is slow.

Most areas of this complex are in grass that is used for wildlife habitat, cut for hay, or used for pasture. A few areas are used for crops. Some areas have potential as a source of sand and gravel. This complex is generally not suited to farming nor to trees. Controlling soil blowing, conserving moisture, and maintaining high-quality vegetation for hay and pasture are the main concerns of management. Capability unit VIs–3; Sioux part in windbreak suitability group 10, Arvilla part in windbreak suitability group 6.

Swenoda Series

The Swenoda series consists of deep, nearly level, moderately well drained soils. These soils are in areas on the delta and between the beaches. They formed in moderately coarse textured glacial melt-water deposits over medium textured glacial melt-water deposits.

In a representative profile the surface layer is black fine sandy loam about 8 inches thick. The subsoil is fine sandy loam about 14 inches thick. The upper part is very dark gray, and the lower part is very dark grayish brown. The underlying material is silt loam. The upper part is gray and has an accumulation of lime, the middle part is light brownish gray, mottled with brown, and has an accumulation of lime, and the lower part is olive brown and mottled with gray.

Permeability is moderately rapid in the surface layer and subsoil and moderate in the underlying material.

The available water capacity is moderate. The organic-matter content and fertility are high. These soils have a deep water table.

Swenoda soils are fairly well suited to farming in most areas and are well suited to trees. Nearly all areas of these soils are used for crops, but a few areas are in grass. The limitations for nonfarm uses are slight to severe.

Representative profile of Swenoda fine sandy loam, in a cultivated field, 1,090 feet east and 1,030 feet south of the northwest corner of sec. 11, T. 145 N., R. 53 W.

Ap—0 to 8 inches, black (10YR 2/1) fine sandy loam, very dark gray (10YR 3/1) when dry; weak coarse blocky structure parting to weak medium granular; slightly hard, very friable, slightly sticky and slightly plastic; common roots and pores; neutral; abrupt smooth boundary.

B21—8 to 14 inches, very dark gray (10YR 3/1) fine sandy loam, dark gray (10YR 4/1) when dry; weak coarse prismatic structure parting to weak coarse blocky; slightly hard, very friable, slightly sticky and slightly plastic; common roots and pores; neutral; clear wavy boundary.

B22—14 to 22 inches, very dark grayish brown (10YR 3/2) fine sandy loam, grayish brown (10YR 5/2) when dry; weak coarse prismatic structure parting to weak coarse blocky; soft, very friable, slightly sticky and slightly plastic; common roots and pores; neutral; gradual wavy boundary.

IIC1ca—22 to 28 inches, gray (10YR 6/1) silt loam, light gray (10YR 7/1) when dry; weak coarse prismatic structure parting to weak medium blocky; slightly hard, friable, sticky and plastic; few roots and common pores; violently effervescent; mildly alkaline; clear wavy boundary.

IIC2ca—28 to 35 inches, light brownish gray (2.5Y 6/2) silt loam, light gray (2.5Y 7/2) when dry; few fine distinct brown mottles; weak coarse prismatic structure parting to weak medium blocky; slightly hard, friable, sticky and plastic; few roots and common pores; violently effervescent; mildly alkaline; gradual wavy boundary.

IIC3—35 to 60 inches, olive brown (2.5Y 4/4) silt loam, light yellowish brown (2.5Y 6/4) when dry; common medium distinct gray (5Y 6/1) mottles; massive; hard, friable, slightly sticky and plastic; strongly effervescent; mildly alkaline.

The solum ranges from 22 to 36 inches in thickness. The A horizon ranges from 8 to 15 inches in thickness. It is black or very dark gray fine sandy loam, sandy loam, or loam. The B horizon ranges from 14 to 21 inches in thickness. It is very dark gray to brown fine sandy loam or sandy loam. The IIC horizon is commonly silt loam or silty clay loam, but it is loam or clay loam glacial till in some places. This horizon is mildly alkaline or moderately alkaline. A thin stone line is at the upper boundary of the IIC horizon in some places.

Swenoda soils are near the Bohnsack, Embden, and Lankin soils. They have a silt loam C horizon, which Embden soils lack. Unlike Bohnsack soils, they lack a layer where lime has accumulated within 16 inches of the surface. They have more sand and less clay in the solum than Lankin soils.

Sv—Swenoda fine sandy loam. This nearly level soil is in areas on the delta and between the beaches. It has the profile described as representative of the series. The surface layer is fine sandy loam in most places, but it is sandy loam in a few places. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Embden fine sandy loam, which makes up not more than 14 percent of this mapping unit. This soil is on plane and slightly convex slopes. A few small wet areas are indicated by a spot symbol on the soil map.

Soil blowing is a severe hazard. The available water capacity is moderate. Runoff is slow.

Nearly all areas of this soil are used for crops, but a few areas are in grass that is cut for hay or used for pasture. This soil is fairly well suited to farming and well suited to trees. Controlling soil blowing and conserving moisture are the main concerns of management. Capability unit IIIe–3M; windbreak suitability group 1.

Sw—Swenoda loam. This nearly level soil is in areas on the delta and between the beaches. It has a profile similar to the one described as representative of the series, but the surface layer is loam instead of fine sandy loam. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Bohnsack loam, which makes up not more than 14 percent of this mapping unit, Emrick loam, which makes up not more than 8 percent, and Tiffany loam, which makes up not more than 6 percent. The Bohnsack soil is on slightly convex slopes, the Emrick soil is on plane and slightly concave slopes, and the Tiffany soil is in shallow depressions and swales. Also included in mapping are a few areas where the Swenoda soil is silty clay or clay at a depth of 20 to 60 inches. A few small wet areas are indicated by a spot symbol on the soil map.

Soil blowing is a moderate hazard. The available water capacity is moderate. Runoff is slow.

Nearly all areas of this soil are used for crops. A few small areas are in grass that is cut for hay or used for pasture. This soil is well suited to farming and to trees. Controlling soil blowing and conserving moisture are the main concerns of management. Capability unit IIe–5; windbreak suitability group 1.

Tiffany Series

The Tiffany series consists of deep, poorly drained, nearly level soils. These soils are in shallow depressions and swales on the delta, between the beaches, and on the glacial lake plain. They formed in medium textured and moderately coarse textured glacial melt-water deposits.

In a representative profile the surface layer is black loam about 10 inches thick. The next layer, about 14 inches thick, is dark grayish brown fine sandy loam mottled with very dark gray. The underlying material is fine sandy loam. The upper part is olive and mottled with very dark gray, and the lower part is gray and mottled with very dark gray and brown.

Permeability is moderately rapid and moderate, and the available water capacity is moderate. The organic-matter content is high, and fertility is medium. These soils have a high water table 1 to 3 feet below the surface.

Tiffany soils are well suited to farming and to trees if excess water is removed. Most areas of these soils are in crops, but a few areas are in grass. The limitations for most nonfarm uses are severe.

Representative profile of Tiffany loam, in an area of Bohnsack-Tiffany loams, in a cultivated field, 1,680 feet south and 110 feet east of the northwest corner of sec. 16, T. 114 N., R. 52 W.

Ap—0 to 7 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) when dry; weak medium subangular

blocky structure parting to weak moderate granular; slightly hard, very friable, slightly sticky and slightly plastic; common roots and pores; neutral; abrupt smooth boundary.

A12—7 to 10 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) when dry; weak coarse blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; common roots and pores; neutral; clear wavy boundary.

ACg—10 to 24 inches, dark grayish brown (2.5Y 4/2) fine sandy loam, grayish brown (2.5Y 5/2) when dry; common fine distinct very dark gray mottles; weak coarse prismatic structure parting to weak coarse blocky; slightly hard, very friable, slightly sticky and slightly plastic; common roots and many pores; neutral; gradual wavy boundary.

C1g—24 to 48 inches, olive (5Y 5/3) fine sandy loam, pale yellow (5Y 7/3) when dry; common medium prominent very dark gray (10YR 3/1) mottles; weak coarse prismatic structure; soft, very friable, slightly sticky and nonplastic; few roots and many pores; slightly effervescent; slightly acid; gradual wavy boundary.

C2g—48 to 60 inches, gray (5Y 5/1) fine sandy loam, light gray (5Y 7/2) when dry; many coarse distinct brown (10YR 4/3) mottles and few medium prominent very dark gray (10YR 3/1) mottles; massive; soft, very friable, slightly sticky and nonplastic; slightly effervescent; slightly acid.

The A horizon ranges from 8 to 24 inches in thickness and from loam to sandy loam. This horizon is neutral or slightly acid. Below the A horizon, to a depth of 60 inches, are few to many, faint to prominent mottles. The AC horizon is dark gray to pale olive fine sandy loam or sandy loam. The Cg horizon is mainly fine sandy loam or sandy loam, but below a depth of 40 inches, it is loam, silt loam, silty clay loam, or clay in some places. This horizon is slightly acid to mildly alkaline.

Tiffany soils formed in material similar to that in which the Arveson, Embden, and Wyndmere soils formed. Unlike Arveson soils, they lack a layer where lime has accumulated within 16 inches of the surface. They are more poorly drained and have mottles nearer the surface than Embden soils. They are more poorly drained than Wyndmere soils.

Tf—Tiffany loam. This nearly level soil is in shallow depressions and swales on the delta, between the beaches, and on the glacial lake plain. The surface layer is loam in most places, but it is fine sandy loam and sandy loam in a few small areas. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Wyndmere fine sandy loam, which makes up not more than 14 percent of this mapping unit. This soil is on the rims of depressions and swales. Also included in mapping are a few areas of soils that are very poorly drained and that have a substratum of clay at a depth of 24 to 40 inches.

Runoff is very slow. In most places water ponds in spring during periods when rainfall is heavy and snow melts rapidly. A high water table is near the surface in spring and during periods of heavy rainfall. Soil blowing is a moderate hazard.

Most areas of this soil are used for crops, but a few areas are in grass that is used for wildlife habitat, cut for hay, or used for pasture. This soil is well suited to farming and to trees if excess water is removed. Removing excess water and controlling soil blowing are the main concerns of management. Capability unit IIw–5; windbreak suitability group 2.

Tonka Series

The Tonka series consists of deep, poorly drained, nearly level soils. These soils are in shallow, closed depressions between the beaches and on the glacial till plain. They formed in medium textured and moderately fine textured local alluvium and the underlying water-worked glacial till.

Figure 14.—**Profile of Tonka silt loam. The dark-colored surface layer and lighter-colored subsurface layer overlie a light-colored, firm subsoil.**

In a representative profile (fig. 14) the surface layer is black silt loam about 8 inches thick. The subsurface layer, about 11 inches thick, is dark grayish brown loam mottled with yellowish brown. The subsoil, about 17 inches thick, is olive gray clay mottled with dark yellowish brown. The underlying material is dark grayish brown clay loam mottled with gray and reddish brown.

Permeability is slow, and the available water capacity is high. The organic-matter content and fertility are high. These soils have a high water table that ranges from 0 to 3 feet below the surface.

Tonka soils are well suited to farming and to trees if excess water is removed. Most areas of these soils are used for crops, but some areas are in grass. The limitations for most nonfarm uses are severe.

Representative profile of Tonka silt loam, in grass,

2,300 feet east and 1,680 feet north of the southwest corner of sec. 19, T. 145 N., R. 53 W.

A1—0 to 8 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) when dry; weak fine granular structure; slightly hard, friable, slightly sticky and slightly plastic; many roots and pores; medium acid; clear wavy boundary.

A2—8 to 19 inches, dark grayish brown (10YR 4/2) loam, light gray (10YR 7/2) when dry; many medium distinct yellowish brown (10YR 5/6) mottles; moderate thin platy structure; slightly hard, very friable, slightly sticky and slightly plastic; common roots and pores; medium acid; clear smooth boundary.

B2t—19 to 36 inches, olive gray (5Y 4/2) clay, olive gray (5Y 5/2) when dry; common medium distinct dark yellowish brown (10YR 4/4) mottles; moderate medium prismatic structure parting to strong fine blocky; hard, very firm, very sticky and very plastic; common roots and pores; continuous clay films on prisms and blocks; medium acid; gradual wavy boundary.

Cg—36 to 60 inches, dark grayish brown (2.5Y 4/2) clay loam, light brownish gray (2.5Y 6/2) when dry; common medium prominent reddish brown (5YR 4/4) mottles and many medium distinct gray 5Y 5/1) mottles; massive; hard, firm, sticky and plastic; slightly effervescent; neutral.

The solum ranges from 22 to 50 inches in thickness. The A1 horizon ranges from 6 to 15 inches in thickness. It is medium acid or slightly acid. It is black or very dark gray loam, silt loam, silty clay loam, or clay loam. The A2 horizon ranges from 4 to 15 inches in thickness. It is medium acid or slightly acid. It is very dark gray to grayish brown loam, silt loam, or silty clay loam. It has few to many, faint to prominent mottles. The B horizon ranges from 12 to 20 inches in thickness. It is medium acid to neutral. The horizon is black to olive gray clay loam, silty clay loam, or clay and has few to many and faint to prominent mottles. The C horizon is slightly to violently effervescent and is neutral or mildly alkaline. It contains segregated lime in some places.

Tonka soils are near the Hamerly, Gilby, and Lankin soils. Unlike Hamerly and Gilby soils, they lack a layer where lime has accumulated within 16 inches of the surface. They are more poorly drained than Lankin soils and have a platy A2 horizon, which those soils do not have.

To—Tonka silt loam. This nearly level soil is in shallow, closed depressions between the beaches and on the glacial till plain. It is on plane and concave slopes. It has the profile described as representative of the series. The surface layer is silt loam in most places, but it is loam and silty clay loam in a few areas. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of either Gilby loam of Vallers loam, which makes up not more than 12 percent of this mapping unit. These soils are on the rims of depressions.

Runoff is ponded. Water ponds in spring and during periods of heavy rainfall. A high water table is at or near the surface in spring and during periods of heavy rainfall.

Some areas of this soil are used for crops, and some areas are in grass that is used for wildlife habitat, cut for hay, or used for pasture. This soil is well suited to farming and to trees if excess water is removed. Removing excess water and maintaining fertility are the main concerns of management. Capability unit IIw–6; windbreak suitability group 2.

Towner Series

The Towner series consists of deep, nearly level, moderately well drained soils. These soils are in broad areas on the delta. They formed in moderately coarse textured and coarse textured glacial melt-water deposits and the underlying medium textured water-worked glacial till.

In a representative profile the surface layer is sandy loam about 17 inches thick. It is black in the upper part and very dark gray in the lower part. The underlying material, to a depth of 31 inches, is grayish brown loamy sand mottled with brown. Below this is light brownish gray loam that has an accumulation of lime in the upper part and grayish brown loam mottled with yellowish brown in the lower part.

Permeability is rapid in the upper part and moderately slow in the lower underlying material. The available water capacity is moderate. The organic-matter content is high, and fertility is medium. These soils have a seasonal water table 3 to 5 feet below the surface.

Towner soils are fairly well suited to farming and well suited to trees. Nearly all areas of these soils are used for crops, but a few small areas are in grass. The limitations for nonfarm uses are slight to severe.

Representative profile of Towner sandy loam, 1 to 3 percent slopes, in a cultivated field, 153 feet north and 126 feet east of the southwest corner of sec. 16, T. 145 N., R. 53 W.

Ap—0 to 8 inches, black (10YR 2/1) sandy loam, very dark gray (10YR 3/1) when dry; weak coarse blocky structure parting to weak medium granular; slightly hard, very friable, slightly sticky and slightly plastic; common roots and pores; slightly acid; abrupt smooth boundary.

A12—8 to 17 inches, very dark gray (10YR 3/1) sandy loam, dark gray (10YR 4/1) when dry; weak coarse prismatic structure parting to weak coarse blocky; soft, very friable, slightly sticky and slightly plastic; common roots and pores; neutral; clear smooth boundary.

C1—17 to 31 inches, grayish brown (10YR 5/12) loamy sand, light brownish gray (10YR 6/12) when dry; few fine distinct brown mottles; weak coarse prismatic structure parting to weak coarse blocky; soft, very friable, slightly sticky and nonplastic; few roots and common pores; few stones in lower part; neutral; clear smooth boundary.

IIC2ca—31 to 40 inches, light brownish gray (2.5Y 6/2) loam, light gray (2.5Y 7/12) when dry; weak coarse prismatic structure; hard, friable, sticky and plastic; few roots and common pores; violently effervescent; mildly alkaline; clear wavy boundary.

IIC3—40 to 60 inches, grayish brown (2.5Y 5/2) loam, light brownish gray (2.5Y 6/2) when dry; common medium prominent yellowish brown (10YR 5/6) mottles; massive; hard, friable, sticky and plastic; strongly effervescent; mildly alkaline.

The A horizon ranges from 12 to 24 inches in thickness. It is sandy loam or loamy sand. The Ap horizon is slightly acid or neutral. The C horizon is neutral or mildly alkaline, very dark grayish brown to light olive brown fine sand or loamy sand. It has few to common mottles that increase in number and distinctness with increasing depth. The depth to the IIC horizon ranges from 20 to 40 inches. This horizon is mainly loam and clay loam glacial till, but it is silt loam lacustrine deposits in some places. It is mildly alkaline or moderately alkaline.

Towner soils are near the Hecla, Maddock, and Rockwell soils. They have a loamy IIC horizon, but Hecla and Maddock soils lack one. They are darker colored to a greater depth than Maddock soils. They are better drained than Rockwell soils and, unlike those soils, lack a layer where lime has accumulated within 16 inches of the surface.

TrA—Towner sandy loam, 1 to 3 percent slopes. This nearly level soil is on plane and slightly convex side slopes in broad areas on the delta.

Included with this soil in mapping are a few small areas where the surface layer is loamy sand. Also included are some areas of Swenoda fine sandy loam, which makes up not more than 12 percent of this mapping unit, and some areas where the soil lacks a finer textured substratum at a depth of 20 to 40 inches and which makes up about 15 percent. A few small wet areas are indicated by a spot symbol on the soil map.

Soil blowing is a severe hazard. Runoff is slow.

Nearly all areas of this soil are used for crops, but a few areas are in grass that is used for hay or pasture. This soil is fairly well suited to farming and well suited to trees. Controlling soil blowing, conserving moisture and improving fertility are the main concerns of management. Capability unit IIIe–3M; windbreak suitability group 1.

Ulen Series

The Ulen series consists of deep, nearly level, somewhat poorly drained soils. These soils are in areas on the delta and between the beaches. They formed in moderately coarse textured and coarse textured glacial melt-water deposits.

In a representative profile the surface layer, about 15 inches thick, is black fine sandy loam in the upper part and very dark gray loamy fine sand in the lower part. The next 27 inches is loamy fine sand that has an accumulation of lime and is mottled with very dark grayish brown. The upper part is grayish brown, and the lower part is light brownish gray. Below this is light brownish gray fine sand mottled with dark brown.

Permeability is rapid, and the available water capacity is low. The organic-matter content is high, and fertility is medium. These soils have a seasonal high water table 1 to 3 feet below the surface.

Ulen soils are fairly well suited to farming and well suited to trees. Most areas of these soils are used for crops, but some areas are in grass. The limitations for most nonfarm uses are moderate and severe.

Representative profile of Ulen fine sandy loam, in grass, 138 feet north and 609 feet west of the southeast corner of sec. 16, T. 144 N., R. 53 W.

A11—0 to 10 inches, black (10YR 2/1) fine sandy loam, very dark gray (10YR 3/1) when dry; weak coarse subangular blocky structure parting to weak medium granular; slightly hard, very friable, slightly sticky and slightly plastic; many roots and common pores; slightly effervescent; mildly alkaline; clear smooth boundary.

A12—10 to 15 inches, very dark gray (10YR 3/1) loamy fine sand, gray (10YR 5/1) when dry; weak coarse prismatic structure parting to weak coarse blocky; soft, very friable, slightly sticky and nonplastic; many roots and common pores; strongly effervescent; mildly alkaline; clear smooth boundary.

ACca—15 to 25 inches, grayish brown (10YR 5/2) loamy fine sand, light brownish gray (2.5Y 6/2) when dry; few fine faint very dark grayish brown mottles; weak coarse prismatic structure parting to weak coarse blocky; soft, very friable, slightly sticky and nonplastic; common roots and pores; strongly effervescent; mildly alkaline; gradual wavy boundary.

C1ca—25 to 42 inches, light brownish gray (2.5Y 6/2) loamy fine sand, light gray (2.5Y 7/2) when dry; common medium distinct very dark grayish brown (10YR 3/2) mottles; weak coarse prismatic structure parting to weak coarse blocky; soft, very friable, slightly sticky and nonplastic; few roots and common pores; strongly effervescent; mildly alkaline; gradual wavy boundary.

C2g—42 to 60 inches, light brownish gray (2.5Y 6/2) fine sand, light gray (2.5Y 7/2) when dry; many coarse prominent dark brown (7.5YR 4/4) mottles; single grained; loose, nonsticky and nonplastic; slightly effervescent; mildly alkaline.

The soil is mildly alkaline or moderately alkaline. The A horizon ranges from 10 to 16 inches in thickness and is fine sandy loam, loamy fine sand, or loamy sand. The ACca and Cca horizons are loamy fine sand or fine sand. The Cca horizon has few to many and faint or distinct mottles. The Cg horizon commonly is fine sand, but below a depth of 40 inches in a few places, it ranges from sand to silt loam.

Ulen soils formed in material similar to that in which the Hecla, Maddock, and Hamar soils formed. They are calcareous at the surface and are more poorly drained than Maddock and Hecla soils. They are mottled nearer the surface than Maddock soils. Unlike Hamar soils, they are calcareous at the surface.

Un—Ulen fine sandy loam. This nearly level soil is in sandy areas on the delta and between the beaches. It has the profile described as representative of the series. The surface layer is fine sandy loam in most places, but it is loamy fine sand and loamy sand in a few areas. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Hamar fine sandy loam, which makes up not more than 12 percent of this mapping unit, and Hecla fine sandy loam, which makes up not more than 6 percent. The Hamar soil is in shallow depressions and swales, and the Hecla soil is on plane and slightly convex higher slopes.

Soil blowing is a severe hazard. A seasonal high water table is near the surface for short periods in spring during periods when rainfall is heavy and snow melts rapidly. Runoff is slow.

Most areas of this soil are used for crops, but some areas are in grass that is used for pasture, cut for hay, or used for wildlife habitat. This soil is fairly well suited to farming and well suited to trees. Controlling soil blowing, improving fertility, and conserving moisture are the main concerns of management. Capability unit IIIe–3; windbreak suitability group 1.

Vallers Series

The Vallers series consists of deep, poorly drained, nearly level soils. These soils are in broad, flat areas between the beaches. They formed in moderately fine textured water-worked glacial till.

In a representative profile the surface layer is black clay loam about 10 inches thick. The underlying material, to a depth of 27 inches, is clay loam that has an accumulation of lime. The upper part is dark gray, and the lower part is olive gray and mottled with gray. Below this is olive gray clay loam mottled with dark yellowish brown and gray.

Permeability is moderately slow, and the available water capacity is high. The organic-matter content is high, and fertility is medium. These soils have a seasonal high water table 1 to 3 feet below the surface.

Vallers soils are well suited to farming and to trees if excess water is removed. Most areas of these soils

are used for crops, but a few areas are in grass. The limitations for most nonfarm uses are severe.

Representative profile of Vallers clay loam, in an area of Vallers-Doran clay loams, in a cultivated field, 135 feet west and 380 feet south of the northeast corner of sec. 15, T. 148 N., R. 52 W.

Ap—0 to 6 inches, black (10YR 2/1) clay loam, dark gray (10YR 4/1) when dry; moderate medium granular structure; hard, firm, sticky and plastic; many roots and pores; strongly effervescent; mildly alkaline; abrupt smooth boundary.

A12—6 to 10 inches, black (10YR 2/1) clay loam, dark gray (10YR 4/1) when dry; weak medium blocky structure parting to moderate medium granular; hard, firm, sticky and plastic; many roots and pores; strongly effervescent; mildly alkaline; clear smooth boundary.

C1gca—10 to 19 inches, dark gray (5Y 4/1) clay loam, light gray (5Y 7/1) when dry; weak medium blocky structure; hard, firm, sticky and plastic; common roots and many pores; tongues of material from the A horizon extend into this horizon; violently effervescent; mildly alkaline; gradual wavy boundary.

C2gca—19 to 27 inches, olive gray (5Y 5/2) clay loam, light gray (5Y 7/2) when dry; common medium distinct gray (5Y 5/1) mottles; weak medium blocky structure; hard, firm, sticky and plastic; few roots and many pores; violently effervescent; mildly alkaline; clear wavy boundary.

C3g—27 to 60 inches, olive gray (5Y 5/2) clay loam, light gray (5Y 7/2) when dry; common medium distinct dark yellowish brown (10YR 4/4) mottles and common medium distinct gray (5Y 5/1) mottles; weak fine subangular blocky structure; hard, firm, sticky and plastic; strongly effervescent; mildly alkaline.

The soil is mildly alkaline or moderately alkaline. It contains 2 to 10 percent rock fragments. The A horizon ranges from 8 to 16 inches in thickness. It is black or very dark gray loam, clay loam, or silty clay loam. The lower part of this horizon has an accumulation of lime in places and mottles in some places. The Cg horizon is clay loam in many places, but is silty clay loam in places. It has few to many, faint to prominent mottles. This horizon is dark gray to light olive gray. It has few or common nests of gypsum crystals in the lower part.

Vallers soils are near the Hamerly, Tonka, and Doran soils. They are more poorly drained than Hamerly soils. Unlike Tonka soils, they have a layer that is high in lime content within 16 inches of the surface. They lack a B horizon, but Doran soils have one.

Vd—Vallers-Doran clay loams. The soils of this complex are nearly level and are in broad areas between the beaches. The Vallers soil is on plane and slightly convex slopes, and the Doran soil is on plane and slightly concave slopes. This complex is at least 55 percent Vallers clay loam and at least 30 percent Doran clay loam. Slopes are 0 to 1 percent.

The Vallers soil has the profile described as representative of the series. The surface layer is clay loam in most places, but it is loam or silty clay loam in a few places. The Doran soil is similar to the one described as representative of the series, but in some areas, it is more poorly drained. The surface layer is clay loam in most places, but it is loam in a few areas.

Included with this complex in mapping are some areas of Hamerly clay loam, which makes up not more than 10 percent of this mapping unit, and areas of Tonka clay loam, which makes up not more than 5 percent. The Hamerly soil is on higher slightly convex slopes, and the Tonka soil is in small, shallow depressions. A few small saline areas and small wet areas are indicated by spot symbols on the soil map.

The hazard of soil blowing is moderate on the Vallers soil and slight on the Doran soil. Runoff is slow on both soils. Some areas are ponded in spring and during periods of heavy rainfall. In most areas, small to large stones interfere with tillage. Most of the stones are concentrated in the upper part of the soils.

Most areas of this complex are used for crops, but a few areas are in grass that is cut for hay, used for pasture, or used for wildlife habitat. This complex is well suited to farming and to trees if excess water is removed. Removing excess water, maintaining and improving fertility and tilth, removing stones, and controlling soil blowing are the main concerns of management. Capability unit IIw–4L; Vallers part in windbreak suitability group 2, Doran part in windbreak suitability group 1.

Viking Series

The Viking series consists of deep, nearly level, poorly drained soils. These soils are in areas between the beaches and on the glacial lake plain. They formed in fine textured glacial lacustrine deposits.

In a representative profile the surface layer is black clay about 7 inches thick. The subsoil, about 18 inches thick, is clay that is very dark gray in the upper part and dark gray in the lower part. The underlying material, to a depth of 34 inches, is olive gray clay that has an accumulation of lime and is mottled with brown. Below this is clay mottled with brown. The upper part is olive gray, and the lower part is olive.

Permeability is very slow, and the available water capacity is high. The organic-matter content and fertility are high. These soils have a seasonal high water table 1 to 3 feet below the surface.

Viking soils are well suited to farming and to trees. Most areas of these soils are used for crops, but a few areas are in grass. The limitations for most nonfarm uses are severe.

Representative profile of Viking clay, in a cultivated field, 150 feet north and 1,305 feet west of the southeast corner of sec. 35, T. 145 N., R. 52 W.

Ap—0 to 7 inches, black (10YR 2/1) clay, dark gray (10YR 4/1) when dry; moderate fine granular structure; hard, firm, very sticky and very plastic; common roots and pores; neutral; abrupt smooth boundary.

B21t—7 to 18 inches, very dark gray (5Y 3/1) clay, dark gray (5Y 4/1) when dry; weak coarse prismatic structure parting to strong very fine blocky; hard, very firm, very sticky and very plastic; common roots and pores; clay films on blocks; mildly alkaline; clear wavy boundary.

B22t—18 to 25 inches, dark gray (5Y 4/1) clay, gray (5Y 6/1) when dry; weak coarse prismatic structure parting to strong very fine blocky; hard, very firm, very sticky and very plastic; few roots and common pores; clay films on blocks; slightly effervescent; mildly alkaline; gradual wavy boundary.

C1ca—25 to 34 inches, olive gray (5Y 5/2) clay; light gray (5Y 7/2) when dry; common fine faint brown mottles; weak fine blocky structure; hard, very firm, very sticky and very plastic; few roots and common pores; violently effervescent; mildly alkaline; gradual wavy boundary.

C2g—34 to 46 inches, olive gray (5Y 5/2) clay, light gray

(5Y 7/2) when dry; many medium distinct brown (10YR 4/3) mottles; massive; hard, very firm, very sticky and very plastic; strongly effervescent; mildly alkaline; gradual wavy boundary.

C3g—46 to 60 inches, olive (5Y 5/3) clay, pale yellow (5Y 7/3) when dry; many medium distinct brown (10YR 4/3) mottles; massive; hard, very firm, very sticky and very plastic; slightly effervescent; mildly alkaline.

Few or common stones and pebbles are on the surface and in the soil. The soil is mildly or moderately alkaline throughout, but the upper 10 inches is neutral or mildly alkaline in some places. The solum ranges from 20 to 36 inches in thickness. The A horizon ranges from 6 to 12 inches in thickness. It is black or very dark gray silty clay or clay. Thin tongues of material from the A horizon extend to a depth of 24 inches in some places. The B horizon ranges from 14 to 24 inches in thickness. The lower part is calcareous in some places.

Viking soils are near the Doran, Fargo, and Hamerly soils. They are more poorly drained and contain more clay than Doran soils. They have few to common stones on the surface and in the soil, but Fargo soils do not have stones. Unlike Hamerly soils, they lack a layer where lime has accumulated within 16 inches of the surface.

Vk—Viking clay. This nearly level soil is in areas between the beaches and on the glacial lake plain. It has the profile described as representative of the series. The surface layer is clay in most places, but it is silty clay in a few places. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Fargo silty clay, which makes up not more than 10 percent of this mapping unit, and Doran clay loam, which makes up not more than 8 percent. The Doran soil is in higher areas. A few small saline areas, small wet areas, and a few small areas of gumbo spots are indicated by spot symbols on the soil map.

Soil blowing is a moderate hazard. Runoff is slow. In a few areas water ponds in spring during periods when rainfall is heavy and snow melts rapidly. In many areas a few small to large stones interfere with tillage.

Most areas of this soil are used for crops, but a few areas are in grass that is cut for hay or used for pasture. This soil is well suited to farming and to trees. Removing excess water, controlling soil blowing, improving and maintaining permeability and tilth, and removing stones are the main concerns of management. Capability unit IIew–4; windbreak suitability group 1.

Wahpeton Series

The Wahpeton series consists of deep, nearly level, moderately well drained soils. These soils are on low levees and terraces along streams. They formed in fine textured alluvium deposited by streams.

In a representative profile the surface layer is silty clay about 30 inches thick. It is black in the upper part and very dark gray in the lower part. The next 20 inches is dark grayish brown silty clay. Below this is a buried surface layer of very dark gray silty clay about 8 inches thick. It is underlain by very dark grayish brown silty clay.

Permeability is moderate, and the available water capacity is high. The organic-matter content and fertility are high. These soils have a deep water table and are subject to flooding by streams.

Wahpeton soils are well suited to farming and to trees. Most areas of these soils are used for crops, but some areas are in grass and native woodland. The limitations for most nonfarm uses are severe.

Representative profile of Wahpeton silty clay, 1 to 3 percent slopes, in grass and native woodland, 570 feet west and 108 feet north of the southeast corner of sec. 23, T. 144 N., R. 49 W.

A11—0 to 4 inches, black (10YR 2/1) silty clay, very dark gray (10YR 3/1) when dry; weak medium subangular blocky structure parting to moderate fine granular; hard, friable, sticky and plastic; many roots and common pores; neutral; abrupt smooth boundary.

A12—4 to 20 inches, black (10YR 2/1) silty clay, very dark gray (10YR 3/1) when dry; weak medium subangular blocky structure parting to moderate fine blocky; hard, friable, sticky and plastic; many roots and common pores; neutral; gradual wavy boundary.

A13—20 to 30 inches, very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) when dry; moderate medium prismatic structure parting to moderate medium blocky; hard, firm, sticky and plastic; common roots and pores; neutral; clear smooth boundary.

C1—30 to 50 inches, dark grayish brown (2.5Y 4/2) silty clay, light brownish gray (2.5Y 6/2) when dry; moderate medium prismatic structure parting to moderate medium blocky; hard, firm, sticky and plastic; few roots and common pores; slightly effervescent; mildly alkaline; abrupt smooth boundary.

A1b—50 to 58 inches, very dark gray (10YR 3/1) silty clay, gray (10YR 5/1) when dry; weak fine blocky structure; hard, firm, sticky and plastic; slightly effervescent; neutral; clear smooth boundary.

C2—58 to 60 inches, very dark grayish brown (2.5Y 3/2) silty clay, dark grayish brown (2.5Y 4/2) when dry; weak fine blocky structure; hard, firm, sticky and plastic; many soft small lime segregations; strongly effervescent; neutral.

The A horizon ranges from 20 to 36 inches in thickness. It is silty clay or clay. The C horizon is very dark gray to grayish brown silty clay or clay. These soils commonly have one or more buried A horizons below a depth of 24 inches. In some places lime segregations are lacking in the lower part of the C horizon.

Wahpeton soils are near the Cashel, Fargo, and Nutley soils. They have a thicker and darker colored A horizon than Cashel soils. They are more permeable and better drained than Fargo soils. They are darker colored to a greater depth than Nutley soils, but unlike those soils, they have a buried A horizon.

WaA—Wahpeton silty clay, 1 to 3 percent slopes. This nearly level soil is on low levees and terraces on bottom lands of the Red and Elm Rivers. The surface layer is silty clay in most places, but it is clay in a few places.

Included with this soil in mapping are some areas of Cashel silty clay, which makes up not more than 10 percent of this mapping unit, and Nutley silty clay, which makes up not more than 6 percent. The Cashel soil is on the lower parts of terraces and levees that are the first areas flooded by streams. The Nutley soil is on short side slopes that extend to bottom lands along streams. Small areas that are steep and have short slopes are indicated by a spot symbol on the soil map.

Runoff is slow. This soil is subject to flooding by streams in spring during periods when rainfall is heavy and snow melts rapidly.

Most areas of this soil are used for crops, but some areas are in grass and native woodland that are used for pasture, cut for hay, or used for wildlife food and cover. This soil is well suited to farming and to trees.

It is difficult to till. Maintaining tilth and high-quality vegetation for hay and pasture are the main concerns of management. Capability unit IIs–4; windbreak suitability group 1.

Wheatville Series

The Wheatville series consists of deep, nearly level, somewhat poorly drained soils. These soils are in areas on the delta and glacial lake plain. They formed in medium textured glacial melt-water deposits and the underlying fine textured glacial lacustrine deposits.

In a representative profile the surface layer is silt loam about 12 inches thick. The upper part is black, and the lower part is very dark gray and has an accumulation of lime. The underlying material, to a depth of 22 inches, is light brownish gray silt loam that has an accumulation of lime and is mottled with brown. The lower part of the underlying material is grayish brown silt loam in the upper part, olive gray clay in the middle part, and olive clay that is mottled with gray and brown in the lower part.

Permeability is moderately rapid in the upper part and slow in the underlying clay substratum. The available water capacity is high. The organic-matter content is high, and fertility is medium. These soils have a seasonal high water table 1 to 3 feet below the surface.

Wheatville soils are well suited to farming and to trees. Nearly all areas of these soils are used for crops. The limitations for nonfarm uses are slight to severe.

Representative profile of Wheatville silt loam, in a cultivated field, 243 feet north and 2,120 feet east of the southwest corner of sec. 10, T. 145 N., R. 51 W.

Ap—0 to 7 inches, black (10YR 2/1) silt loam, very dark gray (10YR 3/1) when dry; weak medium granular structure; slightly hard, friable, sticky and plastic; common roots and pores; strongly effervescent; mildly alkaline; abrupt smooth boundary.

A12ca—7 to 12 inches, very dark gray (10YR 3/1) silt loam, gray (10YR 5/1) when dry; weak coarse blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common roots and pores; violently effervescent; mildly alkaline; clear wavy boundary.

C1ca—12 to 22 inches, light brownish gray (10YR 6/2) silt loam, white (10YR 8/2) when dry; few fine faint brown mottles; weak medium prismatic structure parting to weak coarse blocky; slightly hard, friable, slightly sticky and slightly plastic; few roots and common pores; violently effervescent; mildly alkaline; gradual smooth boundary.

C2—22 to 29 inches, grayish brown (2.5Y 5/3) silt loam, light gray (2.5Y 7/3) when dry; weak medium prismatic structure parting to weak coarse blocky; slightly hard, friable, slightly sticky and slightly plastic; few roots and common pores; strongly effervescent; mildly alkaline; clear wavy boundary.

IIC3—29 to 35 inches, olive gray (5Y 5/2) clay, light gray (5Y 7/2) when dry; weak medium prismatic structure parting to moderate fine blocky; hard, firm, very sticky and very plastic; few roots and common pores; strongly effervescent; mildly alkaline; gradual wavy boundary.

IIC4—35 to 60 inches, olive (5Y 5/3) clay, pale yellow (5Y 7/3) when dry; few medium distinct gray (5Y 5/1) mottles and common medium distinct brown (10YR 4/3) mottles; massive; very hard, very firm, very sticky and very plastic; strongly effervescent; mildly alkaline.

The A horizon ranges from 6 to 15 inches in thickness. It is loam or silt loam. The Cca horizon ranges from 6 to 16 inches in thickness. It is dark grayish brown or grayish brown silt loam or loam. The C horizon is silt loam, loam, or very fine sandy loam. The IIC horizon ranges from 20 to 40 inches in depth. It is dark gray to pale olive silty clay or clay and has few to many, faint to prominent mottles in some places.

Wheatville soils are near the Borup, Gardena, and Glyndon soils. They are better drained than Borup soils. They have a finer textured C horizon than Borup and Glyndon soils. They lack a B horizon, but Gardena soils have one.

Wh—Wheatville silt loam. This nearly level soil is in areas on the delta and glacial lake plain. It has the profile described as representative of the series. The surface layer is silt loam in most places, but it is loam in a few places. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Glyndon silt loam, which makes up not more than 14 percent of this mapping unit, and Borup silt loam, which makes up not more than 8 percent. The Borup soil is in shallow swales and depressions. A few small wet areas and small areas that are steep and have short slopes are indicated by spot symbols on the soil map.

Soil blowing is a moderate hazard. Runoff is very slow. In a few areas water ponds in spring during periods when rainfall is heavy and snow melts rapidly.

Nearly all areas of this soil are used for crops. This soil is well suited to farming and to trees. Controlling soil blowing and improving fertility are the main concerns of management. Capability unit IIe–4L; windbreak suitability group 1.

Wyndmere Series

The Wyndmere series consists of deep, nearly level, somewhat poorly drained soils. These soils are on beaches and in broad areas on the delta and between the beaches. They formed in moderately coarse textured glacial melt-water deposits.

In a representative profile the surface layer is fine sandy loam about 14 inches thick. The upper part is black, and the lower part is very dark gray and has an accumulation of lime. The underlying material, to a depth of 27 inches, is fine sandy loam that has an accumulation of lime. It is gray in the upper part and light brownish gray in the lower part. Below this is fine sandy loam that is light olive brown in the upper part and olive gray and mottled with dark brown in the lower part.

Permeability is moderately rapid. The available water capacity is moderate, except in saline areas. The organic-matter content is high, and fertility is medium. These soils have a seasonal high water table 3 to 5 feet below the surface.

Wyndmere soils are fairly well suited to farming and are well suited to trees in most areas. Most areas of these soils are used for crops, but a few areas are in grass. The limitations for nonfarm uses are slight to severe.

Representative profile of Wyndmere fine sandy loam, in an area of Wyndmere-Tiffany fine sandy loams, in a cultivated field, 2,590 feet east and 108 feet north of the southwest corner of sec. 3, T. 144 N., R. 53 W.

Ap—0 to 8 inches, black (10YR 2/1) fine sandy loam, very dark gray (10YR 3/1) when dry; moderate medium granular structure; soft, very friable, slightly sticky and slightly plastic; common roots and

pores; slightly effervescent; neutral; abrupt smooth boundary.

A12ca—8 to 14 inches, very dark gray (10YR 3/1) fine sandy loam, dark gray (10YR 4/1) when dry; weak coarse prismatic structure parting to weak coarse blocky; soft, very friable, slightly sticky and slightly plastic; common roots and pores; violently effervescent; mildly alkaline; clear wavy boundary.

C1ca—14 to 20 inches, gray (10YR 5/1) fine sandy loam, light gray (10YR 6/1) when dry; weak coarse prismatic structure parting to weak coarse blocky; soft, very friable, slightly sticky and slightly plastic; common roots and pores; violently effervescent; mildly alkaline; clear wavy boundary.

C2ca—20 to 27 inches, grayish brown (2.5Y 5/2) fine sandy loam, light gray (2.5Y 7/2) when dry; weak coarse prismatic structure parting to weak coarse blocky; soft, very friable, slightly sticky and slightly plastic; few roots and common pores; violently effervescent; mildly alkaline; clear wavy boundary.

C3—27 to 46 inches, light olive brown (2.5Y 5/4) fine sandy loam, light yellowish brown (2.5Y 6/4) when dry; few fine distinct gray mottles; weak coarse subangular blocky structure; few roots and common pores; slightly effervescent; mildly alkaline; gradual wavy boundary.

C4g—46 to 60 inches, olive gray (5Y 5/2) fine sandy loam, light gray (5Y 7/2) when dry; common medium prominent dark brown (7.5Y 4/4) mottles; single grained; soft, very friable, slightly sticky and slightly plastic; slightly effervescent; mildly alkaline.

These soils are mildly alkaline or moderately alkaline throughout, but parts of the surface layer are neutral in some places. The A horizon ranges from 7 to 15 inches in thickness. It is fine sandy loam, sandy loam, very fine sandy loam, or loam. The C horizon is dark gray to pale olive and commonly is sandy loam or fine sandy loam, but below a depth of 40 inches in places, it ranges from sand to silty clay. It has few to many, faint to prominent mottles. Gypsum crystals and soluble salts are common in some places. The Cca horizon is dark gray to grayish brown sandy loam, fine sandy loam, or light loam.

Wyndmere soils are near the Arveson, Glyndon, and Tiffany soils. They are better drained than Arveson soils. They are better drained than Tiffany soils and, unlike those soils, have a layer where lime has accumulated within 16 inches of the surface. They contain more sand and less silt than Glyndon soils.

Wn—Wyndmere fine sandy loam. This nearly level soil is on narrow to broad beaches and in broad areas on the delta and between the beaches. It has a profile similar to the one described as representative of the series, but in a few areas the surface layer is not so thick. The surface layer is fine sandy loam in most places, but it is sandy loam or very fine sandy loam in a few places. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Tiffany fine sandy loam, which makes up not more than 15 percent of this mapping unit. This soil is in shallow swales and depressions. Also included in mapping are small areas where slopes are 3 to 6 percent. Small wet areas are indicated by a spot symbol on the soil map.

Runoff is slow. Soil blowing is a severe hazard.

Most areas of this soil are used for crops, but a few areas are in grass that is cut for hay or used for pasture. This soil is fairly well suited to farming and well suited to trees. Controlling soil blowing, improving fertility, and conserving moisture are the main concerns of management. Capability unit IIIe–3; windbreak suitability group 1.

Wo—Wyndmere loam. This nearly level soil is in broad areas on the delta and between the beaches. It has a profile similar to the one described as representative of the series, but the surface layer is loam in most places. In a few places, it is very fine sandy loam instead of loam. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Tiffany loam, which makes up not more than 14 percent of this mapping unit. This soil is in shallow swales and depressions. Small wet areas and a few small saline areas are indicated by spot symbols on the soil map.

Soil blowing is a moderate hazard. Runoff is slow.

Most areas of this soil are used for crops, but a few areas are in grass that is cut for hay or used for pasture. This soil is well suited to farming and to trees. Controlling soil blowing, improving fertility, and conserving moisture are the main concerns of management. Capability unit IIe–4L; windbreak suitability group 1.

Ws—Wyndmere loam, saline. This nearly level soil is in areas on the delta and between the beaches. It has a profile similar to the one described as representative of the series, but it is moderately saline and the surface layer is loam. Slopes are 0 to 1 percent.

Included with this soil in mapping are some areas of Tiffany loam, which makes up not more than 15 percent of this mapping unit, and Wyndmere soils that are not saline, which make up about 15 percent. The Tiffany soil is in shallow swales and depressions.

The available water capacity is low. This soil contains enough soluble salts to affect plant growth. Soil blowing is a moderate hazard. Runoff is slow.

Some areas of this soil are used for crops, and some areas are in grass that is used for pasture, cut for hay, or used for wildlife habitat. This soil is fairly well suited to farming, but it is not suited to trees. Controlling salinity, selecting salt-tolerant crops, improving fertility, and controlling soil blowing are the main concerns of management. Capability unit IIIs–4L; windbreak suitability group 10.

Wt—Wyndmere-Tiffany fine sandy loams. The soils of this complex are nearly level and are in broad areas on the delta and between the beaches. The Wyndmere soil is calcareous at or near the surface and is on plane and slightly convex slopes. The Tiffany soil is in small, shallow depressions. This complex is at least 55 percent Wyndmere fine sandy loam and at least 36 percent Tiffany fine sandy loam. Slopes are 0 to 1 percent.

The Wyndmere soil has the profile described as representative of the series. The Tiffany soil has a profile similar to the one described as representative of the series, but the surface layer is fine sandy loam.

Included with this complex in mapping are some areas of Embden fine sandy loam, which makes up not more than 9 percent of this mapping unit. This soil is on plane and higher slightly convex slopes. Also included in mapping are a few areas where these soils have a surface layer of loam or very fine sandy loam. A few small saline areas are indicated by a spot symbol on the soil map.

Runoff is slow on the Wyndmere soil and very slow on the Tiffany soil. In most areas, water ponds on the Tiffany soil in spring during periods when rainfall is heavy and snow melts rapidly. Soil blowing is a severe hazard.

Most areas of this complex are used for crops, but a few areas are in grass that is cut for hay or used for pasture. This complex is fairly well suited to farming and, if excess water is removed, is well suited to trees. Controlling soil blowing, removing excess water, and improving and maintaining fertility are the main concerns of management. Capability unit IIIe–3; Wyndmere part in windbreak suitability group 1, Tiffany part in windbreak suitability group 2.

Zell Series

The Zell series consists of deep, sloping to moderately steep, well drained soils. These soils are on beaches and breaks to drainageways and streams on the delta, between the beaches, and on the glacial lake plain. They formed in medium textured glacial meltwater deposits.

In a representative profile the surface layer is black silt loam about 7 inches thick. The underlying material, to a depth of 18 inches, is grayish brown silt loam. Below this is silt loam that is olive brown and mottled with yellowish brown in the upper part and light olive brown and mottled with yellowish brown and gray in the lower part.

Permeability is moderate, and the available water capacity is high. The organic-matter content is moderate, and fertility is low. These soils have a deep water table.

Zell soils are generally not suited to farming in most areas but are fairly well suited to trees. Most areas of these soils are in grass, but some areas are in native woodland, and a few are used for crops. The limitations for nonfarm uses range from slight to severe.

Representative profile of Zell silt loam, 9 to 25 percent slopes, in a cultivated field, 132 feet east and 1,960 feet north of the southwest corner of sec. 30, T. 144 N., R. 50 W.

Ap—0 to 7 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) when dry; weak medium granular structure; soft, very friable, slightly sticky and slightly plastic; common roots and pores; slightly effervescent; neutral; abrupt smooth boundary.

C1—7 to 18 inches, grayish brown (2.5Y 5/2) silt loam, light gray (2.5Y 7/2) when dry; weak coarse prismatic structure parting to weak coarse blocky; soft, very friable, slightly sticky and slightly plastic; common roots and pores; strongly effervescent; mildly alkaline; clear wavy boundary.

C2—18 to 36 inches, olive brown (2.5Y 4/4) silt loam, pale yellow (2.5Y 7/4) when dry; few fine distinct yellowish brown mottles; weak coarse blocky structure; soft, very friable, slightly sticky and slightly plastic; few roots and common pores; slightly effervescent; mildly alkaline; gradual wavy boundary.

C3—36 to 60 inches, light olive brown (2.5Y 5/4) silt loam, pale yellow (2.5Y 7/4) when dry; common medium distinct yellowish brown (10YR 5/6) mottles and common medium distinct gray (5Y 5/1) mottles; massive; soft, very friable, slightly sticky and slightly plastic; slightly effervescent; mildly alkaline.

The soil is mildly alkaline or moderately alkaline, but the A horizon is neutral in places. The A horizon ranges from 5 to 10 inches in thickness. It is black or very dark gray loam or silt loam. The C horizon is dark grayish brown to light yellowish brown loam, silt loam, or very fine sandy loam.

Zell soils formed in material similar to that in which the Eckman, Gardena, and Glyndon soils formed. They lack a B horizon, but Eckman and Gardena soils have one. They have a thinner A horizon than Gardena soils. Unlike Glyndon soils, they lack a layer where lime has accumulated within 16 inches of the surface.

ZeE—Zell silt loam, 9 to 25 percent slopes. This strongly sloping to moderately steep soil is in narrow areas on breaks to drainageways and streams on the delta, between the beaches, and on the glacial lake plain. It has the profile described as representative of the series. The surface layer is silt loam in most places, but it is loam in a few places.

Included with this soil in mapping are some areas of Eckman silt loam, which makes up not more than 14 percent of this mapping unit, and Gardena silt loam, which makes up not more than 8 percent. The Eckman soil is on slightly convex lower side slopes, and the Gardena soil is on plane and slightly concave lower side slopes. The soils similar to the Zell soils have a lighter colored surface layer than is representative of the Zell series. A few small areas that are steep and have short slopes are indicated by a spot symbol on the soil map.

Runoff is rapid. This soil is highly susceptible to water erosion.

Most areas of this soil are in grass and native woodland. They are used for pasture, cut for hay, or used for wildlife habitat. A few areas are used for crops. This soil is generally not suited to farming but is fairly well suited to trees in most areas. Maintaining high-quality vegetation for hay, pasture, and erosion control are the main concerns of management. Capability unit VIe–4; windbreak suitability group 8.

Use and Management of the Soils

In this section use and management of the soils for crops is discussed. The system of capability classification used by the Soil Conservation Service is explained, and estimated yields of principal crops are given. Use of the soils for windbreaks, wildlife habitat, and recreation facilities are also discussed. Information about engineering uses of the soils is given, mainly in tables.

Management of the Soils for Crops

About 90 percent of the acreage in Traill County is cultivated. The principal crops are spring wheat, barley, oats, potatoes, sugar beets, and hay. The main concerns of management are reducing excessive wetness, controlling soil blowing, conserving moisture, and maintaining fertility. Other problems are controlling water erosion and overcoming salinity, poor tilth, and stoniness.

In this county, excessive wetness generally means water that ponds on the surface in spring and during periods of heavy rainfall, and that the soils have a seasonal water table. A system of field drains, road ditches, and floodways carries the ponded water to streams and rivers and also lowers the seasonal water table in some places. Drainage makes it possible for timely tillage and seeding operations to take place.

Among the measures used to help control soil blowing are cover crops, stripcropping, buffer strips, wind-

breaks, minimum tillage, timely tillage, emergency tillage, and use of crop residue. Generally a combination of several measures is used.

Conserving moisture in dryfarmed areas generally means reducing evaporation, limiting runoff, increasing infiltration, and controlling weeds. Among the effective measures are stubble mulching, stripcropping, field windbreaks, buffer strips, timely tillage, minimum tillage, use of crop residue, and application of fertilizer. Fallow helps to control weeds.

Among the measures that help to maintain fertility are the application of chemical fertilizer, the use of green manure and barnyard manure, and the inclusion in the cropping system of cover crops, grasses, and legumes, as well as the use of summer fallow. Controlling soil blowing and water erosion also helps to conserve fertility.

Improving soil tilth, removing stones, and reducing salinity are needed to offset the effects of unfavorable soil characteristics.

Capability grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The soils are grouped according to their limitations when used, and the way they respond to treatment (*9*). The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops requiring special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for forest trees or for engineering.

In the capability system, the kinds of soil are grouped at three levels: the capability class, the subclass, and the unit. These levels are discussed in the following paragraphs.

CAPABILITY CLASSES, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

Class I soils have few limitations that restrict their use. (None in Traill County.)

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Class V soils are subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife habitat. (None in Traill County.)

Class VI soils have several limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife habitat.

Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture or range, woodland, or wildlife habitat. (None in Traill County.)

Class VIII soils and landforms have limitations that preclude their use for commercial crop production and restrict their use to recreation, wildlife habitat, or water supply, or to esthetic purposes.

CAPABILITY SUBCLASSES are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c* shows that the chief limitation is climate that is too cold or too dry.

CAPABILITY UNITS are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIc–6 or IIIe–3. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass or kind of limitation as defined in the foregoing paragraph; and the Arabic numeral specifically identifies the capability unit within each subclass.

For some soils two limitations are of about equal importance, and the subclass symbol indicates both, for example, IIew–4. Also, a few capability units have a capital letter, L, M, or P, after the Arabic numeral, for example, IIe–4L. The letter L indicates that most of the soils in this capability unit have a limy surface layer. The letter M indicates that the soils are underlain by a finer textured substratum. The letter P indicates that nearly all or some of the soils in the capability unit have a claypan.

In the following pages the capability units in Traill County are described and suggestions for the use and management of the soils are given.

CAPABILITY UNIT IIe–4

This unit consists of Nutley silty clay, 3 to 6 percent slopes, which is a deep, well drained soil on beaches, breaks to drainageways, and bottom lands along streams.

This soil slakes down to sand-size particles if it is plowed in fall. It is then moderately susceptible to soil blowing in winter and early in spring. It is moderately susceptible to water erosion. This soil is hard when dry and very sticky when wet. Runoff is medium, the available water capacity is high, and permeability is

slow. The organic-matter content is moderate, and fertility is medium. Soil blowing and water erosion are the major hazards.

This soil is well suited to wheat, oats, barley, alfalfa, and if protective measures are used to control erosion, it is well suited to sugar beets, potatoes, flax, and sunflowers. It is also suited to grasses, trees, and other uses.

The major management needs are practices that control water erosion and soil blowing and improve and maintain organic-matter content, tilth, and fertility. The use of crop residue, timely tillage, cover crops, stripcropping, stubble-mulch tillage, commercial fertilizer, and grassed waterways helps to improve and maintain organic-matter content, tilth, and permeability as well as to control soil blowing and water erosion. This soil is difficult to till. Tillage can be done only within a narrow range of moisture content if good tilth is to be maintained.

CAPABILITY UNIT IIe-4L

This unit consists of deep, nearly level, somewhat poorly drained and moderately well drained soils on the lake plain, on the delta, and in interbeach areas. These soils have a surface layer of loam, silt loam, and silty clay loam. In most areas there are no stones, but in some areas small to large stones interfere with tillage. In nearly all areas, these soils have an accumulation of lime, but in a few areas, free lime is lacking in the surface layer and subsoil.

Because of the accumulation of lime, to which a seasonal high water table contributes, the surface layer slakes down readily to sand-size particles and then the soils are moderately susceptible to soil blowing. In nearly all areas the high water table is 1 to 5 feet below the surface in spring and during periods of heavy rainfall. Runoff is slow to very slow, permeability ranges from moderately rapid to slow, and the available water capacity is high in nearly all areas but moderate in a few. Fertility is medium in most areas but high in some areas. The organic-matter content is high. Soil blowing is the major hazard.

These soils are well suited to wheat, oats, barley, flax, soybeans, sunflowers, sweetclover, alfalfa, and, except in some stony areas, to sugar beets, potatoes, and pinto beans. They are also suited to grasses, trees, and other uses.

The major management needs are practices that control soil blowing, improve fertility, and maintain tilth. Stubble-mulch tillage, stripcropping, cover crops, buffer strips, and field windbreaks help to control soil blowing. Using crop residue, applying commercial fertilizer, and growing green manure crops help to improve and maintain fertility and tilth. Drainage is needed in a few areas where water ponds on the surface.

CAPABILITY UNIT IIe-5

This unit consists of deep, nearly level to gently sloping, well drained and moderately well drained soils on the delta, between the beaches, and on the glacial till plain. These soils have a surface layer of very fine sandy loam, loam, or silt loam. In nearly all areas there are no stones, but in a few areas small to large stones interfere with tillage.

The available water capacity is high on most of the acreage, but it is moderate in some areas. Runoff is slow in most areas, but in a few areas it is medium. Permeability is moderately rapid to moderately slow. Fertility is high in most places, but it is medium in a few places. The organic-matter content is high. These soils are moderately susceptible to soil blowing and water erosion. Soil blowing, and water erosion on gently sloping soils are the major hazards.

These soils are well suited to wheat, oats, barley, flax, soybeans, sunflowers, alfalfa, and, except in a few stony areas, to sugar beets, potatoes, and pinto beans. They are also suited to grasses, trees, and other uses.

The major management needs are practices that control soil blowing and water erosion and conserve moisture. The use of stubble-mulch tillage, crop residue, cover crops, stripcropping, buffer strips (fig. 15), field windbreaks, and grassed waterways helps to control soil blowing and water erosion and conserve moisture.

CAPABILITY UNIT IIe-6

This unit consists of Overly-Great Bend silty clay loams, 3 to 6 percent slopes, which is a complex of deep, well drained and moderately well drained soils on beaches, breaks to drainageways, and bottom lands along streams on the delta and glacial lake plain.

Fertility is high on most of the acreage, but it is medium in some areas. The organic-matter content is high. Runoff is slow on most of the acreage, but it is medium in some areas. The available water capacity is high, and permeability is moderate and moderately slow. These soils have a deep water table. Soil blowing is a slight hazard. Water erosion is the major hazard.

The soils in this complex are well suited to wheat, oats, barley, alfalfa, and if protective measures are used to control water erosion, it is well suited to sugar beets, potatoes, soybeans, flax, and sunflowers. They are also suited to grasses, trees, and other uses.

The major management needs are practices that control water erosion and maintain and improve fertility and tilth. The use of crop residue, cover crops, stubble-mulch tillage, green-manure crops, and grassed waterways helps to control water erosion and maintain and improve fertility and tilth. These soils tend to clod if tilled when wet.

CAPABILITY UNIT IIw-4

This unit consists of deep, nearly level, poorly drained soils on the lake plain and between the beaches. These soils have a surface layer of clay and silty clay. In most areas there are no stones, but in a few areas small to large stones interfere with tillage.

Runoff is slow to ponded, the available water capacity is high, and permeability is slow and very slow. The organic-matter content is high. Fertility is high in most areas, but it is medium in some areas. These soils are moderately susceptible to soil blowing. They are hard and very hard when dry and very sticky when wet. Occasionally some of these soils are flooded in spring if drainage ditches are plugged with snow. Excess water and soil blowing are the major problems.

These soils are well suited to wheat, oats, barley, flax, sunflowers, sweet clover, alfalfa, and sugar beets

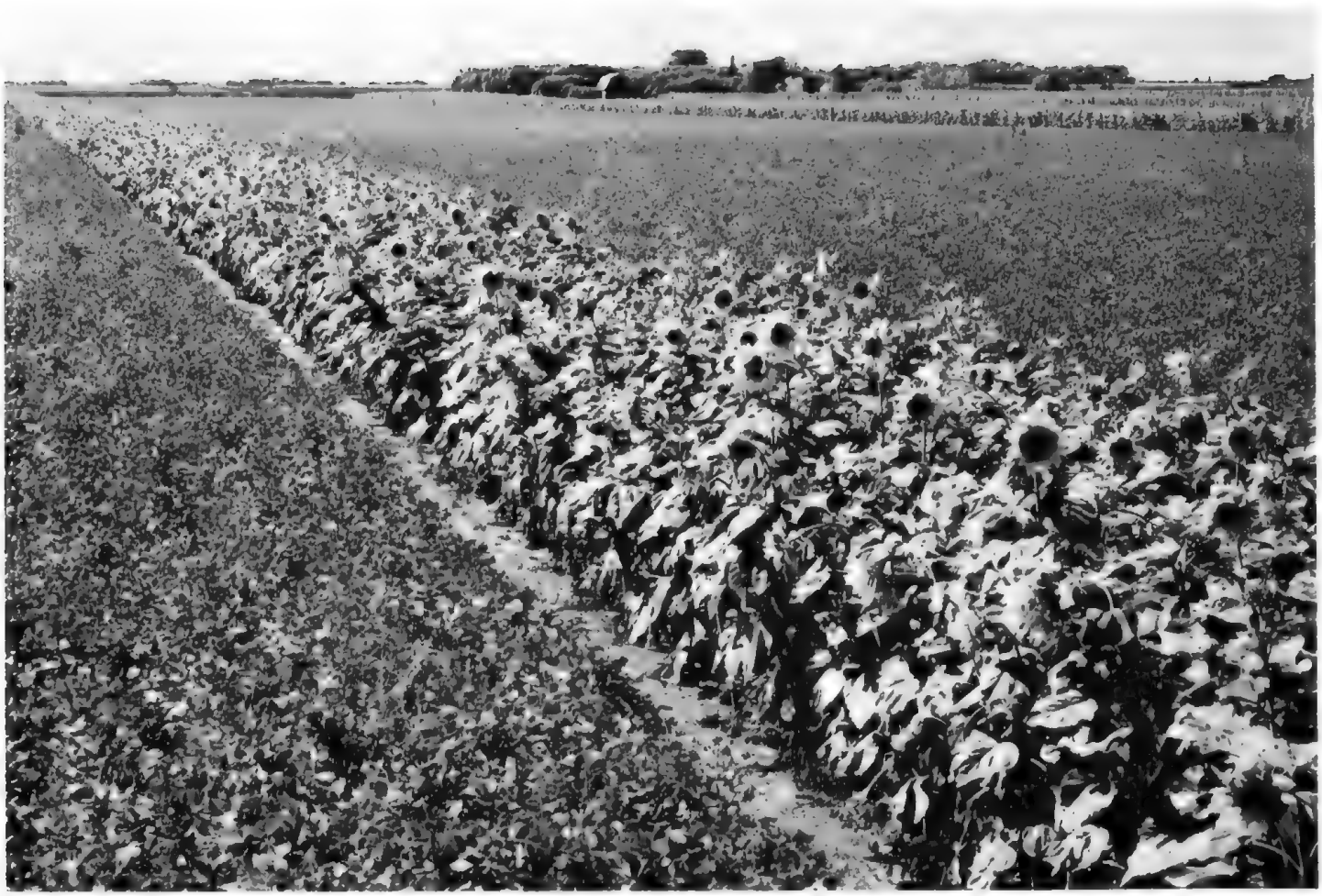

Figure 15.—**Buffer strips of sunflowers in a field of pinto beans protect the soils from blowing. The soils are in capability unit IIe–5.**

and potatoes. They are also suited to grasses, trees, and other uses.

The major management needs are practices that control soil blowing, remove excess water, and improve and maintain fertility, tilth, and permeability. The use of crop residue, cover crops, buffer strips, and field windbreaks helps to control soil blowing. Using crop residue, green manure crops (fig. 16), timely tillage, land shaping and leveling, and drainage ditches helps to remove excess water and improve and maintain fertility, tilth, and permeability. Drainage ditches are needed and must be maintained to prevent ponding. In most places these soils are drained by a system of road ditches and field drains. They are plowed in fall to provide a suitable seedbed in spring, but fall plowing allows the clods to slake down to granules through wetting and drying and freezing and thawing. The soil granules are easily moved by wind, and the drifting soil plugs drainage ditches and accumulates on field boundaries. These soils are difficult to till, and tillage must be done within a narrow range of moisture content.

CAPABILITY UNIT IIew–4L

This unit consists of deep, nearly level, somewhat poorly drained and poorly drained soils on the lake plain, on the delta, and between the beaches. These soils have a surface layer of loam, silt loam, clay loam, and silty clay loam. The somewhat poorly drained soils are on slightly convex slopes in broad, flat areas. They contain large amounts of lime. The poorly drained soils are in shallow depressions and swales. They lack free lime in the surface layer and subsoil. In most areas there are no stones, but in some areas small to large stones interfere with tillage.

Runoff is slow and very slow on the soils that contain large amounts of lime. Because of the content of lime, the surface layer slakes down readily to sand-size particles and then the soils are moderately susceptible to soil blowing. Runoff is very slow and ponded on the soils in depressions that lack free lime in the surface layer and subsoil. Soil blowing is a slight hazard on these soils. A seasonal high water table is 0 to 5 feet below the surface in spring and during periods of heavy rainfall. Occasionally, some of these

Figure 16.—**A green manure crop of sweetclover being plowed down to improve tilth, fertility, and permeability. The soils are in capability unit IIew–4.**

soils are flooded in spring if drainage ditches are plugged with snow. The available water capacity is high in nearly all areas, but it is moderate in a few areas. Permeability is moderately rapid to slow. Fertility is medium in most areas, but it is high in some areas. The organic-matter content is high. Soil blowing and excess water are the major problems.

If drained, these soils are well suited to wheat, oats, barley, sunflowers, soybeans, alfalfa, and, except in some stony areas, to sugar beets, potatoes, and pinto beans. If not drained, these soils are not so well suited to crops because the excess water interferes with tillage and the growth of plants. These soils are also suited to grass and other uses. They are suited to trees if adequately drained.

The major management needs are practices that control soil blowing, remove excess water, and maintain and improve fertility and tilth. The use of crop residue, stubble-mulch tillage, buffer strips, stripcropping, green manure crops, commercial fertilizer, and field windbreaks helps to control soil blowing and maintain and improve fertility and tilth. The surface layer in some areas is loam and silt loam that is easily tilled, but in some areas it is clay loam and silty clay loam that tends to clod if tilled when wet. Using land shaping and leveling and drainage ditches helps to remove excess water. These soils are drained by a system of road ditches and field drains in most places.

CAPABILITY UNIT IIw–4

This unit consists of deep, nearly level, poorly drained soils in shallow depressions and swales on the glacial lake plain. These soils have a surface layer of silty clay.

The organic-matter content and fertility are high. These soils are hard and very hard when dry and very sticky when wet. Permeability is slow in most areas but very slow in a few areas. Runoff is very slow and ponded, and the available water capacity is high. A seasonal high water table is 0 to 5 feet below the surface in spring and during periods of heavy rainfall. Occasionally some of these soils are flooded in spring when drainage ditches are plugged with snow. If drained, these soils are moderately susceptible to soil blowing. Excess water on the surface is the major problem.

If drained, these soils are well suited to wheat, oats, barley, flax, sugar beets, sunflowers, and alfalfa. If not drained, these soils are not so well suited to cultivated crops because the excess water interferes with tillage and the growth of crops. These soils are also suited to grasses, trees, and other uses.

The major management needs are practices that remove excess water and maintain and improve tilth and permeability. The use of crop residue, green manure crops, timely tillage, land shaping and leveling, and drainage ditches helps to remove excess water and to improve and maintain tilth and permeability. These soils are difficult to till, and tillage can be done only within a narrow range of moisture content if good tilth is to be maintained. Drainage systems are needed to remove excess water, and they must be maintained to prevent ponding. In most places these soils are drained by a system of road ditches and field drains.

CAPABILITY UNIT IIw-4L

This unit consists of deep, nearly level, poorly drained and somewhat poorly drained soils in shallow depressions, swales, seepage areas, and abandoned stream channels on low flood plains, and in broad, flat areas on the delta, between the beaches, on the lake plain, and on bottom lands along streams. These soils have a surface layer of loam, silt loam, or clay loam. In most areas there are no stones, but in a few areas small to large stones interfere with tillage. In nearly all areas these soils contain a large amount of lime, but in a few areas, they contain only moderate and small amounts.

Because of the accumulation of lime, to which a seasonal high water table contributes, the surface layer slakes down readily to sand-size particles, and then the soils are moderately susceptible to soil blowing. In nearly all areas the seasonal high water table is 1 to 3 feet below the surface in spring and during periods of heavy rainfall. Runoff is slow or very slow, and permeability is moderately rapid to slow. The available water capacity is high in most areas but moderate in a few. Occasionally, some of these soils are flooded in spring when drainage ditches are plugged with snow. The organic-matter content is high. Excess water is the major problem.

If drained, these soils are well suited to wheat, barley, oats, sunflowers, alfalfa, and trees, and, except in a few stony areas, to potatoes and sugar beets. If not drained, they are not so well suited to cultivated crops because water interferes with tillage and the growth of plants. In some undrained areas these soils are too wet for cultivated crops, and in these areas are best suited to grass and other uses.

The major management needs are practices that remove excess water and improve fertility. The use of crop residue, green manure crops, commercial fertilizer, and drainage ditches helps to remove excess water and to improve fertility. Drainage ditches are needed to remove excess water, and they must be maintained to prevent ponding. These soils are drained by a system of road ditches and field drains in some places.

CAPABILITY UNIT IIw-5

This unit consists of Tiffany loam, which is a deep, poorly drained soil in shallow depressions and swales on the delta, on the lake plain, and between the beaches.

The organic-matter content is high, and fertility is medium. The available water capacity is moderate, permeability is moderate and moderately rapid, and runoff is very slow. A seasonal high water table is 1 to 3 feet below the surface in spring and during periods of heavy rainfall. Occasionally this soil is flooded in spring when drainage ditches are plugged with snow. If drained, this soil is moderately susceptible to soil blowing. Excess water is the major problem.

If adequately drained, this soil is well suited to wheat, oats, barley, flax, soybeans, sunflowers, pinto beans, potatoes, and alfalfa. If not drained, it is not so well suited to crops because the excess water interferes with tillage and with the growth of plants. This soil is also suited to grasses, trees, and other uses.

The major management needs are practices that remove excess water and control soil blowing. Drainage ditches are needed in most areas to remove excess water, and in most places, this soil is drained by a system of road ditches and field drains. The ditches must be maintained to prevent ponding. The use of cover crops, stubble mulch tillage, and field windbreaks helps to control soil blowing.

CAPABILITY UNIT IIw-6

This unit consists of deep, nearly level, poorly drained and somewhat poorly drained soils in shallow depressions and swales on the lake plain, between the beaches, on the delta, on the glacial till plain, and in broad, flat areas on the lake plain. These soils have a surface layer of silt loam or silty clay loam.

The organic-matter content and fertility are high. The available water capacity is high, permeability is moderate to slow, and runoff is very slow or ponded. A seasonal high water table is 0 to 5 feet below the surface in spring and during periods of heavy rainfall. Occasionally, some of these soils are flooded in spring when drainage ditches are plugged with snow. If these soils are drained, soil blowing is a slight hazard. The ponding of excess water on the surface is the major problem.

If adequately drained, these soils are well suited to wheat, oats, barley, potatoes, sunflowers, sugar beets, and alfalfa and to trees. If not drained, these soils are not so well suited to cultivated crops because excess water interferes with tillage and with the growth of crops. A few undrained areas are too wet for cultivation and are best suited to grass and wildlife habitat.

The major management needs are practices that remove excess water, maintain fertility, and maintain and improve tilth and permeability. Land shaping and leveling and drainage ditches help to remove excess water. Applying commercial fertilizer helps to maintain fertility. The use of crop residue, green manure crops, and timely tillage helps to maintain and improve tilth and permeability. Drainage ditches are needed to remove excess water, but they must be maintained to prevent ponding. In some places these soils are drained by a system of road ditches and field drains.

CAPABILITY UNIT IIs-4

This unit consists of deep, nearly level, well drained to somewhat poorly drained soils on the lake plain and bottom lands along streams. These soils have a surface layer of silty clay.

Fertility is high in most areas, but it is medium in a few. The organic-matter content is high in some areas and moderate in other areas. These soils are hard and very hard when dry and very sticky when wet. Runoff is slow in nearly all areas, but it is medium in a few. The available water capacity is high, and permeability is moderate to slow. The soils on bottom lands are subject to flooding by streams in spring when snow melts rapidly and rainfall is heavy. The soils on the lake plain are moderately susceptible to soil blowing. Tilth is the major problem.

These soils are well suited to wheat, oats, barley, sugar beets, potatoes, sunflowers, and alfalfa. They are also suited to grasses, trees, and other uses.

The major management needs are practices that improve or maintain tilth, fertility, and organic-matter content and control soil blowing. The use of crop residue, commercial fertilizer, green manure crops, and

timely tillage helps to improve or maintain tilth, fertility, and organic-matter content. Using cover crops, stripcropping, stubble-mulch tillage, and field windbreaks helps to control soil blowing on the lake plain. These soils are difficult to till, and tillage can be done only within a narrow range of moisture content if good tilth is to be maintained.

CAPABILITY UNIT IIc–6

This unit consists of deep, nearly level, well drained to poorly drained soils in broad areas, on low terraces and levees on flood plains, on beaches, and in elevated areas of the lake plain, on the delta, between the beaches, and on bottom lands along streams. These soils have a surface layer of loam, silt loam, clay loam, silty clay loam, and silty clay. In most areas there are no stones, but in a few areas small to large stones interfere with tillage.

Fertility is high in nearly all areas but medium in a few. The organic-matter content is high in nearly all areas but moderate in a few. Runoff is slow in nearly all areas, but it is very slow or medium in a few areas. The available water capacity is high, and permeability is slow to moderate. The soil blowing hazard is slight in nearly all areas but moderate in a few, and the water erosion hazard is slight. Lack of moisture and a short growing season are the major problems.

These soils are well suited to wheat, oats, barley, flax, soybeans, sunflowers, alfalfa, and, except in some stony areas, to sugar beets, potatoes, and pinto beans. They are also suited to grasses, trees, and other uses.

The major management needs are practices that conserve moisture, maintain tilth, and improve and maintain fertility and organic-matter content. The use of crop residue, stubble-mulch tillage, and commercial fertilizer helps to conserve moisture and to improve and maintain organic-matter content, tilth, and fertility. In some areas where the surface layer is clay loam, silty clay loam, and silty clay, the soil tends to clod if it is tilled when wet.

CAPABILITY UNIT IIIe–3

This unit consists of deep, nearly level to gently sloping soils on beaches and breaks to drainageways and streams and in broad areas on the glacial till plain and between the beaches. Most of these soils are well drained and moderately well drained, but some are somewhat poorly drained. The soils have a surface layer of sandy loam and fine sandy loam.

The organic-matter content is high in nearly all areas but moderate in a few. Fertility is medium in most areas, but it is high in some areas and low in a few. Runoff is slow and medium, and permeability is moderately rapid to rapid. The available water capacity is moderate in most areas, but it is low in some areas. The somewhat poorly drained soils have a seasonal high water table 1 to 5 feet below the surface. Soil blowing is the major problem.

These soils are fairly well suited to wheat, oats, barley, bromegrass, and if measures are used to control soil blowing, to potatoes, sunflowers, soybeans, pinto beans, and alfalfa. They are also suited to grasses, trees, and other uses.

The major management needs are practices that control soil blowing, conserve moisture, and improve and maintain organic-matter content and fertility. The use of crop residue, stubble-mulch tillage, stripcropping, cover crops, buffer strips, commercial fertilizer, and field windbreaks helps to control soil blowing, conserve moisture, and improve and maintain organic-matter content and fertility. Surface drainage is needed in a few areas where water ponds on the surface in spring and during periods of heavy rainfall.

CAPABILITY UNIT IIIe–3M

This unit consists of deep, nearly level, moderately well drained soils in broad areas between the beaches and on the delta. These soils have a surface layer of sandy loam and fine sandy loam.

Permeability is rapid and moderately rapid in the upper part and moderately slow in the underlying material. The available water capacity is moderate, and runoff is slow. Fertility is high in some areas, but it is medium in other areas. The organic-matter content is high. Soil blowing is the major hazard.

These soils are fairly well suited to wheat, barley, oats, and if measures are used to control erosion, to potatoes, pinto beans, soybeans, sunflowers, flax, and alfalfa. They are also suited to grasses, trees, and other uses.

The major management needs are practices that control soil blowing, conserve moisture, and maintain and improve fertility. The use of crop residue, stubble-mulch tillage, stripcropping, cover crops, buffer strips, commercial fertilizer, and field windbreaks helps to control soil blowing, conserve moisture, and improve and maintain fertility.

CAPABILITY UNIT IIIe–4

This unit consists of Nutley silty clay, 6 to 9 percent slopes, which is a deep, well drained soil on beaches and breaks to drainageways and bottom lands along streams of the glacial lake plain.

The organic-matter content is moderate, and fertility is medium. This soil is hard when dry and very sticky when wet. The available water capacity is high, permeability is slow, and runoff is medium. This soil is highly susceptible to water erosion and moderately susceptible to soil blowing. Water erosion is the major hazard.

This soil is fairly well suited to wheat, oats, barley, and if measures are used to control water erosion, to sugar beets, sunflowers, soybeans, potatoes, flax, and alfalfa. It is also suited to grasses, trees, and other uses.

The major management needs are practices that control water erosion and improve and maintain organic-matter content, fertility, and tilth. The use of crop residue, timely tillage, commercial fertilizer, grasses in the crop rotation, cover crops, stubble-mulch tillage, and grassed waterways helps to control water erosion and improve and maintain organic-matter content, fertility, and tilth. This soil is difficult to till. Tillage must be done at the proper moisture content to maintain good tilth.

CAPABILITY UNIT IIIe–5

This unit consists of deep, sloping and rolling, well drained and moderately well drained soils on beaches, breaks to drainageways, and bottom lands along

streams and in areas on the glacial till plain, on the delta, and between the beaches. These soils have a surface layer of loam and silt loam.

The available water capacity is high, permeability is moderate, and runoff is medium and rapid. The organic-matter content is high in most areas but moderate in a few. Fertility is medium in some areas, but high in some areas and low in a few. These soils are highly susceptible to water erosion and moderately susceptible to soil blowing. Water erosion is the major hazard.

These soils are fairly well suited to wheat, oats, barley, and if measures are used to control water erosion, to flax, sunflowers, pinto beans, soybeans, and alfalfa. They are also suited to grasses, trees, and other uses.

The major management needs are practices that control water erosion and soil blowing, conserve moisture, and improve and maintain organic-matter content and fertility. The use of crop residue, stubble-mulch tillage, commercial fertilizer, cover crops, stripcropping, grassed waterways, and field windbreaks helps to control water erosion and soil blowing, conserve moisture, and improve and maintain organic-matter content and fertility.

CAPABILITY UNIT IIIe–6

This unit consists of Great Bend silty clay loam, 6 to 9 percent slopes, which is a deep, well drained soil on ridges of the delta, breaks to drainageways and streams of the delta, between the beaches, and on the glacial lake plain.

The available water capacity is high, permeability is moderate, and runoff is medium. The organic-matter content is high, and fertility is medium. This soil tends to clod if it is tilled when wet. This soil is highly susceptible to water erosion. Soil blowing is a slight hazard, and water erosion is the major hazard.

This soil is fairly well suited to wheat, oats, barley, and if protective measures are used to control water erosion, to flax, sunflowers, and alfalfa. It is also suited to grasses, trees, and other uses.

The major management needs are practices that control water erosion, maintain and improve tilth and fertility, and conserve moisture. The use of crop residue, cover crops, timely tillage, stubble-mulch tillage, grasses in crop rotation, contour tillage, and grassed waterways helps to control water erosion, maintain and improve tilth and fertility, and conserve moisture.

CAPABILITY UNIT IIIew–3

This unit consists of deep, nearly level, poorly drained soils in shallow depressions, swales, and seepage areas and in broad areas on the delta and between beaches. These soils have a surface layer of fine sandy loam.

A seasonal high water table is 1 to 3 feet below the surface. Runoff is very slow, and water ponds in some areas in spring and during periods of heavy rainfall. Permeability is moderately rapid to moderately slow, and the available water capacity is moderate in most areas but high in some. The organic-matter content is high, and fertility is medium. These soils are highly susceptible to soil blowing. Soil blowing and excess water are the major hazards.

If drained, these soils are fairly well suited to wheat, oats, barley, sunflowers, and alfalfa and well suited to trees. If not drained, they are generally suited to grass, wildlife habitat, and other uses.

The major management needs are practices that control soil blowing, remove excess water, and improve fertility. The use of crop residue, stubble-mulch tillage, stripcropping, cover crops, buffer strips, commercial fertilizer, field windbreaks, and drainage ditches helps to control soil blowing, remove excess water, and improve fertility. Drainage is needed in most areas where water interferes with the growth of plants and with tillage.

CAPABILITY UNIT IIIes–3

This unit consists of nearly level and gently sloping soils that are moderately deep and shallow to sand and gravel. These soils are on beaches. They have a surface layer of sandy loam.

The organic-matter content is high, and fertility is medium. The available water capacity is low. Permeability is moderately rapid in the surface layer and subsoil and very rapid in the underlying sand and gravel. These soils are highly susceptible to soil blowing. Soil blowing and low available water capacity are the major problems.

These soils are fairly well suited to wheat, oats, barley, and if measures are used to control soil blowing, to sunflowers, soybeans, pinto beans, and alfalfa. They are also suited to grasses and other uses. They are poorly suited to trees in most areas.

The major management needs are practices that control soil blowing, conserve moisture, and improve fertility. The use of crop residue, stubble-mulch tillage, stripcropping, cover crops, buffer strips, commercial fertilizer, and field windbreaks helps to control soil blowing, conserve moisture, and improve fertility.

CAPABILITY UNIT IIIw–4

This unit consists of deep, nearly level, poorly drained and very poorly drained soils in depressions, swales, and drainageways, on low flood plains, and in abandoned stream channels on the lake plain, delta, and bottom lands along streams. They have a surface layer of silty clay.

The organic-matter content is high. Fertility is high in most areas, but it is medium in a few. These soils are hard and very hard when dry and very sticky when wet. The available water capacity is high, and permeability is slow and very slow. Runoff is ponded in most areas, but it is very slow in a few. A seasonal high water table is 0 to 3 feet below the surface. Soil blowing is a moderate hazard in drained areas. Water ponding on the surface is the major problem.

If drained, these soils are fairly well suited to wheat, oats, barley, flax, sunflowers, and alfalfa and well suited to trees. If not drained, they are best suited to water-tolerant grasses, wildlife habitat, and other uses.

The major management needs are practices that remove excess water and maintain and improve tilth and permeability. The use of crop residue, green manure crops, cover crops, and drainage ditches helps to remove excess water and maintain and improve permeability and tilth. Where adequate outlets are available, drainage helps to remove the excess water that inter-

feres with the growth of plants and with tillage. These soils are difficult to till. Tillage can be done only within a narrow range of moisture content if good tilth is to be maintained.

CAPABILITY UNIT IIIs–4L

This unit consists of deep, nearly level, somewhat poorly drained and poorly drained, saline soils in broad areas, seepage areas, depressions, and swales on the lake plain, on the delta, and between the beaches. These soils have a surface layer of loam, silt loam, and clay loam. In most areas there are no stones, but in a few areas small to large stones interfere with tillage. In most areas these soils are saline, but in a few areas they are not. In nearly all areas these soils contain large amounts of lime, but in a few areas free lime is lacking in the surface layer and subsoil.

Because of the accumulation of lime, to which a seasonal high water table contributes, the surface layer slakes down readily to sand-size particles, and then the soils are moderately susceptible to soil blowing. The seasonal high water table is 0 to 5 feet below the surface in spring and during periods of heavy rainfall. It also contributes to the accumulations of salts other than lime. Runoff is slow and very slow in nearly all areas, but it is ponded in some areas. Permeability is moderately rapid to slow. The available water capacity is moderate in most areas, but it is high in a few areas and low in a few others. Fertility is medium in nearly all areas, but it is high in a few. The organic-matter content is high. The saline soils contain enough soluble salts to affect the growth of plants. The salts restrict the penetration of roots and limit the kinds of plants that can be grown. Salinity is the major hazard.

These soils are fairly well suited to salt-tolerant crops of wheat, oats, barley, sweetclover, and alfalfa and suited to grasses and other uses. If not drained, they are suited to grasses and other uses. They are not suited to trees.

The major management needs are the choice of salt-tolerant crops and practices that control salinity, improve and maintain fertility and tilth, control soil blowing, and remove excess water. The use of crop residue, green manure crops, commercial fertilizer, stubble-mulch tillage, and drainage helps to control salinity, maintain and improve fertility and tilth, control soil blowing, and remove excess water. Drainage is needed in some areas where water ponds on the surface.

CAPABILITY UNIT IIIs–4P

This unit consists of Fargo-Ryan silty clays, which is a complex of a deep, clayey soil and a soil that is shallow to a claypan. These soils are nearly level and poorly drained and are in broad areas on the lake plain.

The claypan subsoil contains large amounts of salt in the lower part. It is exposed by plowing in nearly all places. The claypan restricts the penetration of roots, air, and moisture. A seasonal high water table is 1 to 5 feet below the surface. The available water capacity is high in the deep, clayey soil and moderate in the claypan soil. Permeability is slow and very slow. Fertility is high, but in the claypan soil it is medium. The organic-matter content is high. The deep, clayey soil is moderately susceptible to soil blowing in winter and early in spring. The shallowness to a claypan is the major problem.

The soils in this complex are fairly well suited to wheat, oats, barley, sweetclover, and alfalfa. They are also suited to grasses and other uses. They are not suited to trees, but some trees are planted for farmstead windbreaks in selected sites.

The major management needs are practices that improve and maintain fertility, tilth, and permeability, remove excess water, and control soil blowing. The use of crop residue; green manure crops; stubble-mulch tillage; timely tillage; a cropping system that includes sweetclover, alfalfa, and grasses; drainage ditches; and commercial fertilizer helps to maintain and improve fertility, permeability, and tilth, remove excess water, and control soil blowing.

These soils are difficult to till. When the claypan is exposed on the surface, it is difficult to prepare a good seed bed. Tillage can be done only within a narrow range of moisture content if tilth is to be maintained.

CAPABILITY UNIT IIIs–5

This unit consists of Renshaw loam, 1 to 3 percent slopes, which is shallow to sand and gravel. This soil is somewhat excessively drained and is on low beaches between the beaches and on the glacial till plain.

The organic-matter content is high, and fertility is medium. The available water capacity is low. Permeability is moderately rapid in the upper part and very rapid in the underlying sand and gravel. Runoff is slow. Soil blowing is a slight hazard in winter and early in spring. Low available water capacity is the major limitation.

This soil is fairly well suited to wheat, oats, barley, sunflowers, and alfalfa. It is also suited to grasses and other uses. It is poorly suited to trees.

The major management needs are practices that conserve moisture and improve fertility. The use of crop residue, stubble-mulch tillage, and commercial fertilizer helps to conserve moisture and improve fertility.

CAPABILITY UNIT IIIs–5P

This unit consists of Nahon silt loam, which is shallow to a claypan. This nearly level, somewhat poorly drained soil is in areas of the delta and between the beaches. The claypan is below the plow layer in nearly all areas, but in a few areas it has been exposed at the surface by plowing. In most areas large amounts of salt are in the lower part of the subsoil.

The organic-matter content is high, and fertility is medium. The available water capacity is moderate, runoff is slow, and permeability is very slow. The claypan restricts the penetration of roots, air, and moisture. This soil is moderately susceptible to soil blowing in winter and early in spring. The claypan is a major serious problem.

This soil is fairly well suited to wheat, oats, barley, flax, sunflowers, sweetclover, and alfalfa. It is also suited to grasses and other uses. It is not suited to trees.

The major management needs are practices that improve permeability, conserve moisture, and control soil blowing. The use of crop residue; stubble-mulch tillage; a cropping system that includes grasses, sweet-

clover, and alfalfa; commercial fertilizer; and stripcropping helps to improve permeability, conserve moisture, and control soil blowing. Where the claypan is exposed at the surface, a good seedbed is difficult to prepare.

CAPABILITY UNIT IIIe–6

This unit consists of Divide loam, which is moderately deep to sand and gravel. This soil is nearly level and somewhat poorly drained and is on low beaches on the delta and between the beaches. It has an accumulation of lime.

The organic-matter content is high, and fertility is medium. The available water capacity is low. Permeability is moderate in the upper part and very rapid in the underlying sand and gravel. A seasonal high water table contributes to the accumulation of lime and is 3 to 5 feet below the surface in spring and during periods of heavy rainfall. This soil is moderately susceptible to soil blowing. Low available water capacity is the major limitation.

This soil is fairly well suited to wheat, oats, barley, sunflowers, and alfalfa. It is also suited to grasses, trees, and other uses.

The major management needs are practices that conserve moisture, improve fertility, and control soil blowing. The use of crop residue, stripcropping, cover crops, field windbreaks, stubble-mulch tillage, buffer strips, and commercial fertilizer help to conserve moisture, control soil blowing, and improve fertility.

CAPABILITY UNIT IVe–2

This unit consists of Hecla loamy fine sand, 1 to 3 percent slopes, which is a deep, moderately well drained soil on low beaches on the delta and between the beaches.

The organic-matter content is high, and fertility is medium. The available water capacity is low, permeability is rapid, and runoff is slow. This soil is highly susceptible to soil blowing. Soil blowing is the major hazard.

This soil is poorly suited to wheat, oats, barley, flax, sunflowers, and alfalfa. It is suited to grasses, trees, and other uses.

The major management needs are practices that control soil blowing, improve fertility, and conserve moisture. The use of crop residue; stubble mulch tillage; cover crops; a cropping system that includes grasses and legumes; commercial fertilizer; stripcropping; and field windbreaks helps to control soil blowing, improve fertility, and conserve moisture.

CAPABILITY UNIT IVe–4

This unit consists of Nutley silty clay, 9 to 15 percent slopes, which is a deep, well drained soil on beaches and breaks to drainageways and on bottom lands along streams of the glacial lake plain.

The organic-matter content is moderate, and fertility is medium. This soil is hard when dry and very sticky when wet. The available water capacity is high, permeability is slow, and runoff is rapid. This soil is very highly susceptible to water erosion and moderately susceptible to soil blowing in winter and early in spring. Water erosion is the major hazard.

This soil is poorly suited to cultivated crops. It is better suited to wheat, oats, barley, flax, and alfalfa than to other crops. It is poorly suited to sunflowers and fairly well suited to trees.

The major management needs are practices that control water erosion and maintain and improve organic-matter content, fertility, and tilth. The use of crop residue, stubble-mulch tillage, commercial fertilizer, grassed waterways, and a cropping system that includes grasses and legumes helps to control water erosion and improve and maintain fertility, organic-matter content, and tilth. This soil is difficult to till, and tillage can be done only within a narrow range of moisture content if good tilth is to be maintained.

CAPABILITY UNIT IVe–6

This unit consists of Great Bend silty clay loam, 9 to 15 percent slopes, which is a deep, well drained soil on breaks to drainageways and bottom lands along streams of the delta and lake plain.

The available water capacity is high, permeability is moderate, and runoff is rapid. The organic-matter content is high, and fertility is medium. This soil tends to clod if it is tilled when wet. This soil is very highly susceptible to water erosion. Soil blowing is a slight hazard in winter and early in spring. Water erosion is the major hazard.

This soil is poorly suited to cultivated crops. It is better suited to wheat, oats, barley, flax, and alfalfa than to other crops. It is poorly suited to sunflowers and fairly well suited to trees.

The major management needs are practices that control water erosion and maintain organic-matter content, fertility, and tilth. The use of crop residue, stubble-mulch tillage, commercial fertilizer, grassed waterways, and a cropping system that includes grasses and legumes helps to control water erosion and maintain fertility, organic-matter content, and tilth.

CAPABILITY UNIT IVew–2

This unit consists of Hamar loamy fine sand, which is a deep, poorly drained soil in shallow depressions and swales on the delta and between the beaches.

The organic-matter content is high, and fertility is medium. The available water capacity is low, permeability is rapid, and runoff is very slow. Occasionally, this soil is flooded in spring when drainage ditches are plugged with snow. If drained, it is very highly susceptible to soil blowing. It has a seasonal high water table in spring and during periods of heavy rainfall. Soil blowing and excess water are the major problems.

This soil is poorly suited to wheat, oats, barley, flax, sunflowers, and alfalfa. It is suited to grasses, trees, and other uses.

The major management needs are practices that control soil blowing, remove excess water, and improve fertility. The use of cover crops, stubble-mulch tillage, and field windbreaks helps to control soil blowing. Using crop residue, green manure crops, commercial fertilizer, and drainage ditches helps to remove excess water and improve fertility. Drainage ditches are needed in most areas and must be maintained to prevent ponding on the surface. This soil is drained by a system of road ditches and field drains in most places.

CAPABILITY UNIT IVw-4L

This unit consists of Playmoor silty clay loam, which is a deep, poorly drained, nearly level soil on low flood plains along streams. This soil is moderately saline. It contains small and moderate amounts of lime throughout the soil profile.

The organic-matter content is high, and fertility is medium. The available water capacity is moderate, permeability is moderately slow, and runoff is slow. This soil is subject to flooding by streams in spring and during periods of high rainfall. It contains enough soluble salts to affect plant growth. The salts restrict the penetration of roots and limit the kinds of plants that can be grown. A seasonal water table that contributes to the accumulation of salts and lime is 1 to 3 feet below the surface in spring and during periods of heavy rainfall. Excess water on the surface and in the soil is the major limitation.

If not drained, this soil is poorly suited to wheat, oats, barley, sweetclover, and alfalfa. If drained, it is fairly well suited to salt-tolerant crops. This soil is best suited to grasses used for pasture or cut for hay, to wildlife habitat, or to other uses. It is not suited to trees.

The major management needs are the choice of salt-tolerant crops and practices that remove excess water, control salinity, and maintain high-quality vegetative cover for hay, pasture, and wildlife habitat. Improvement of drainage, control of salinity, and selection of salt-tolerant grasses help to improve and maintain a high-quality cover of plants used for hay, pasture, and wildlife habitat. The use of drainage ditches, crop residue, green manure crops, and other measures helps to remove excess water and control salinity. Drainage is needed, but adequate outlets are generally not available. If outlets are available, surface drains can be used.

CAPABILITY UNIT VIe-2

This unit consists of Serden-Maddock loamy sands, 1 to 6 percent slopes, which is a complex of deep, well drained and excessively drained soils on the delta.

The organic-matter content is moderate and low, and fertility is low. Permeability is rapid, and the available water capacity is low. There is very little runoff because nearly all the precipitation that falls on these soils is absorbed. These soils are very highly susceptible to soil blowing. Low available water capacity and soil blowing are the major problems.

The soils in this complex are generally not suited to cultivated crops, but they can be used for hay and pasture. Nearly all areas of this complex are in native grass that is used for pasture. A few small areas are bare.

The major management needs are practices that maintain a high-quality cover of plants and that control soil blowing. Regulating grazing and reseeding where necessary help to maintain an adequate, high-quality cover. Overgrazing allows the less desirable grasses and weeds to spread and increases the hazard of soil blowing.

CAPABILITY UNIT VIe-4

This unit consists of deep, strongly sloping to moderately steep, well drained soils on breaks to drainageways and bottom lands along streams of the glacial lake plain and delta. These soils have a surface layer of silt loam or silty clay.

The available water capacity is high, permeability is moderate or slow, and runoff is rapid. The organic-matter content is moderate, and fertility is medium or low. Water erosion is the major hazard.

These soils are generally not suited to cultivated crops because they are strongly sloping, moderately steep, and very highly susceptible to water erosion. They are better suited to grass that is used for pasture. Most of the acreage is in grass, but some areas have been broken up for the seeding of small grains.

The major management needs are practices that maintain a cover of high-quality plant cover for forage and that control water erosion. Good pasture management, which consists of proper stocking, deferred grazing, and proper seasonal use, helps to maintain and improve a cover of high-quality plant cover and to control water erosion. Cultivated areas should be reseeded to suitable grasses.

CAPABILITY UNIT VIw-4

This unit consists of Cashel silty clay, channeled, which is a deep, somewhat poorly drained soil on flood plains along streams. This soil is nearly level to sloping and on very short, convex and concave banks of the Red River.

The available water capacity is high, and permeability is moderately slow. The organic-matter content is moderate, and fertility is high. This soil is subject to frequent flooding by streams in spring and during periods of heavy rainfall. It is also subject to water erosion that results from flooding.

Generally areas of this soil are too irregular in shape or slope for cultivation. Nearly all areas are in native woodland, but a few areas are used for pasture. Some areas of native woodland are used for pasture, but some areas are used for wildlife habitat and other purposes.

The major management needs are practices that maintain a high-quality vegetative cover. Deferred grazing, proper stocking, and proper seasonal use help to maintain high-quality cover of plants and to control erosion.

CAPABILITY UNIT VIs-3

This unit consists of Sioux-Arvilla complex, 1 to 6 percent slopes, which are shallow and moderately deep to sand and gravel. These soils are somewhat excessively drained and excessively drained and are on beaches of the delta and between the beaches. They have a surface layer of gravelly sandy loam and sandy loam.

Runoff is slow, permeability is moderately rapid and very rapid, and the available water capacity is very low to low. The organic-matter content is low in most areas, but moderate in some areas. Fertility is medium and low. These soils are susceptible to soil blowing. The very low and low available water capacity is the major problem.

The soils in this complex are generally not suited to cultivated crops. They are better suited to grasses that are cut for hay or used for pasture, and most of the acreage is used for this purpose. Although gen-

erally not suited to crops, these soils are cultivated in some areas. They are not suited to trees, but a few trees are planted on sites selected for farmstead windbreaks.

The main management needs are practices that maintain a high-quality plant cover and that control soil blowing. Good pasture management, which consists of proper stocking, deferred grazing, and proper seasonal use, helps to maintain a high-quality plant cover and to control erosion. Cultivated areas should be reseeded to suitable grasses.

CAPABILITY UNIT VIs–6

This unit consists of Ojata silty clay loam, which is a deep, nearly level, poorly drained, saline soil in broad, shallow swales and depressions of the glacial lake plain and delta and between the beaches. This soil contains a large amount of lime.

This soil contains large amounts of soluble salts that affect plant growth. These salts restrict the growth of roots and limit the kinds of plants that can be grown. A seasonal water table that contributes to the accumulation of lime and salts is 1 to 3 feet below the surface in spring and during periods of heavy rainfall. Runoff is very slow, permeability is slow, and the available water capacity is moderate. The organic-matter content is high, and fertility is low. Salinity is the major problem.

This soil is generally not suited to cultivated crops because of the high salt content. It is better suited to grass that is cut for hay or used for pasture. Although generally not suited to crops, this soil is used for small grain in a few areas. It is not suited to trees.

The major management needs are practices that control salinity and remove excess water. Improvement of drainage and good pasture management, which consists of proper stocking, deferred grazing, and proper seasonal use, help to control salinity, maintain high-quality plant cover, and remove excess water. Cultivated areas should be reseeded to suitable grasses.

CAPABILITY UNIT VIIIw–6

This unit consists of Marsh, which is under water most of the time. It cannot be used for farming, but it provides an excellent habitat for waterfowl. The vegetation consists mainly of cattails, bulrushes, reeds, and other aquatic plants.

Predicted yields

Predicted yields of the principal crops grown in Traill County, under two levels of management, are shown in table 2. These predictions are based on information obtained from farmers and other agricultural workers in the county. The figures represent averages that can be expected over a period long enough to include years of both favorable and unfavorable temperatures and moisture supply during the growing season. The predictions represent acreage planted rather than acreage harvested.

Windbreaks[2]

Traill County has approximately 7,600 acres of native woodland. Most of the wooded areas are on the Cashel, Wahpeton, Fairdale, La Prairie, and LaDelle soils on bottom lands along the Red, Goose, and Elm Rivers and on the Nutley, Great Bend, and Zell soils in adjacent drainageways and on breaks.

The principal trees and shrubs are American basswood, American elm, American plum, boxelder, bur oak, common chokecherry, green ash, hackberry, juneberry, and redosier dogwood.

Windbreaks have been planted to help protect farmsteads and livestock since the days of the early settlers. They are still needed in areas immediately adjacent to some of the farmsteads. The use of field windbreaks to control soil blowing is a recent development. Thousands of acres of cropland in Traill County need some form of protection against wind. When properly designed, field windbreaks can effectively control soil blowing (fig. 17).

Windbreaks return many economic and environmental benefits to the landowner. They distribute and hold snow and prevent it from drifting around the farmstead; they protect buildings and livestock from cold, wintery winds and thus reduce fuel and feed costs; they protect field crops, gardens, and orchards from strong damaging winds and thus reduce the hazards of erosion and evaporation; and they provide a suitable habitat for many kinds of birds and other wildlife.

Factors to be considered before a windbreak is planted are the purpose of planting, the suitability of soils, the adaptability of trees and shrubs, and location. Improperly designed windbreaks can cause many problems.

The establishment of a windbreak and the continued growth of the trees depend on the careful selection of the site and the kinds of trees and shrubs planted. Adequate site preparation before planting and adequate maintenance after planting are also required. Grass and weeds should be eliminated before the trees are planted, and the regrowth of the ground cover should be controlled for the entire life of the windbreak. Some replanting is likely to be needed during the first 2 years.

Windbreak suitability groups

The soils of North Dakota have been grouped into 10 windbreak suitability groupings, all of which occur in Traill County. Under good management the growth response of adapted trees and shrubs is generally the same for all soils within a group.

Several factors are considered in grouping soils, but the dominant and most critical factor is the amount and seasonal availability of soil moisture. Hence, in most groups the soils have a rather wide range of slope and texture of the surface layer. These two soil characteristics largely determine the degree of water erosion and soil blowing. Slope also determines the need for water and soil conservation practices on soils having no other limitations.

The hazard of soil blowing is very severe if the soil is coarse textured, severe if moderately coarse textured, moderate to slight if medium textured, slight if moderately fine textured, and severe if fine textured. There is no hazard, or only a slight hazard, of water erosion if the slope is 0 to 3 percent. The hazard is moderate if the slope is 3 to 6 percent, severe if 6 to 9

[2] By DAVID L. HINTZ, forester, Soil Conservation Service.

TABLE 2.—*Predicted average yields per acre of principal crops*

[Figures in the A columns are yields under average management; those in the B columns are yields under improved management. Dashes indicate that the crop is not suited to the soil]

Soil	Wheat		Oats		Barley		Sugar beets		Potatoes		Hay	
	A	B	A	B	A	B	A	B	A	B	A	B
	Bu	*Bu*	*Bu*	*Bu*	*Bu*	*Bu*	*Tons*	*Tons*	*Cwt*	*Cwt*	*Tons*	*Tons*
Arveson fine sandy loam [1]	17	24	31	46	22	38					1.5	2.2
Arveson loam [1]	17	24	31	46	22	38					1.5	2.2
Arvilla sandy loam, 1 to 6 percent slopes	14	21	25	44	18	34					1.2	1.9
Bearden silt loam, saline	21	29	38	62	27	46	9.0	11.5	90	110	1.8	2.6
Bearden silty clay loam	33	43	60	90	43	69	13.0	17.0	140	180	2.9	3.8
Bearden silty clay loam, clay substratum	33	43	60	90	43	69	13.0	17.0	140	180	2.9	3.8
Bearden-Lindaas silty clay loams [1]	31	41	56	88	41	66	12.5	16.0	135	170	2.7	3.6
Bearden-Overly silty clay loams	34	44	61	93	44	70	13.0	17.0	145	185	2.9	3.9
Bearden-Perella silty clay loams [1]	31	41	56	88	41	66	12.5	16.0	135	170	2.7	3.6
Bearden and Glyndon silt loams	33	43	60	90	43	69	13.0	17.0	140	180	2.9	3.8
Beotia silt loam	35	45	63	95	46	72	13.0	17.0	150	190	3.0	4.0
Bohnsack loam	29	39	52	80	37	62					2.4	3.3
Bohnsack-Tiffany loams [1]	28	38	50	76	36	60					2.2	3.2
Borup silt loam [1]	24	33	43	70	31	53	9.0	12.0	105	130	2.1	2.9
Borup silt loam, saline [1]	15	21	27	44	20	34					1.3	1.9
Cashel silty clay, 1 to 3 percent slopes	28	38	51	77	36	61	10.5	13.5	120	150	2.4	3.3
Cashel silty clay, channeled												
Colvin silt loam [1]	24	33	43	70	31	53	9.0	12.0	105	130	2.1	2.9
Colvin silt loam, saline [1]	15	21	27	44	20	34					1.3	1.9
Cut and fill land [2]												
Divide loam	23	32	41	66	30	51	8.5	11.0	95	120	1.9	2.7
Doran clay loam	31	41	56	88	41	66					2.7	3.6
Dovray silty clay [1]	24	33	43	70	31	53	9.0	12.0	105	130	2.1	2.9
Egeland loam, 1 to 3 percent slopes	26	35	47	73	34	56	10.0	12.5	110	140	2.3	3.1
Egeland-Embden fine sandy loams, 1 to 3 percent slopes	24	33	43	70	31	53	9.0	12.0	105	130	2.1	2.9
Egeland-Embden fine sandy loams, 3 to 6 percent slopes	21	29	38	59	27	46	8.0	10.0	90	110	1.8	2.6
Embden fine sandy loam	25	34	45	70	32	55	10.0	12.5	110	140	2.2	3.0
Embden very fine sandy loam	27	37	49	75	35	58	10.5	13.0	115	145	2.3	3.2
Emrick loam	33	43	60	90	43	69					2.9	3.8
Emrick-Heimdal loams, 1 to 3 percent slopes	31	41	56	88	41	66					2.7	3.6
Fairdale silt loam, 1 to 3 percent slopes	30	40	54	84	39	64	11.0	14.5	125	160	2.5	3.4
Fargo silty clay loam	33	43	60	90	43	69	11.5	15.0	110	140	2.8	3.7
Fargo silty clay	31	41	56	88	41	66	11.0	14.5	105	130	2.7	3.6
Fargo-Dovray silty clays [1]	26	35	43	70	34	56	10.0	12.5	105	130	2.3	3.1
Fargo-Enloe silty clay loams [1]	31	41	56	88	41	66	10.5	14.0	105	130	2.7	3.6
Fargo-Enloe silty clays [1]	28	38	47	77	36	61	10.5	13.5	105	130	2.4	3.3
Fargo-Hegne silty clays	30	40	54	84	39	64	10.5	13.5	105	130	2.5	3.4
Fargo-Ryan silty clays	21	29	38	54	27	46					1.8	2.6
Galchutt-Fargo complex [1]	33	43	60	90	43	69	11.5	15.0	110	140	2.8	3.7
Gardena silt loam	35	45	63	95	46	72	13.0	17.0	150	190	3.0	4.0
Gardena-Eckman silt loams, 3 to 6 percent slopes	31	41	56	88	41	66	11.5	15.0	135	170	2.7	3.6
Gardena-Zell silt loams, 6 to 9 percent slopes	21	29	38	59	27	46	8.0	10.0	90	110	1.8	2.6
Gilby loam	24	33	43	70	31	53					2.1	2.9
Gilby-Tonka complex [1]	24	33	43	70	31	53					2.1	2.9

TABLE 2.—*Predicted average yields per acre of principal crops*—Continued

Soil	Wheat		Oats		Barley		Sugar beets		Potatoes		Hay	
	A	B	A	B	A	B	A	B	A	B	A	B
	Bu	*Bu*	*Bu*	*Bu*	*Bu*	*Bu*	*Tons*	*Tons*	*Cwt*	*Cwt*	*Tons*	*Tons*
Gilby-Tonka complex, saline [1]	19	27	34	59	29	43					1.7	2.4
Glyndon silt loam	33	43	60	90	43	69	13.0	17.0	140	180	2.9	3.8
Glyndon silt loam, saline	21	29	38	62	27	46	9.0	11.5	90	110	1.8	2.6
Glyndon-Perella silt loams [1]	31	41	56	88	41	66	12.5	16.0	135	170	2.7	3.6
Glyndon-Tiffany loams [1]	30	40	54	84	39	64	11.5	15.0	125	160	2.5	3.4
Grano silty clay [1]	21	29	38	59	27	46	8.0	10.0	90	110	1.8	2.6
Great Bend silty clay loam, 1 to 3 percent slopes	31	41	56	88	41	66	11.5	15.0	135	170	2.7	3.6
Great Bend silty clay loam, 6 to 9 percent slopes	21	29	38	59	27	46	8.0	10.0	90	110	1.8	2.6
Great Bend silty clay loam, 9 to 15 percent slopes	14	20	25	37	18	32					1.2	1.8
Hamar loamy fine sand [1]	19	27	34	57	29	43	8.0	10.0	90	110	1.8	2.6
Hamerly-Tonka clay loams [1]	24	33	43	70	31	53					2.1	2.9
Hamerly-Tonka clay loams, saline [1]	19	27	34	59	29	43					1.7	2.4
Hecla loamy fine sand, 1 to 3 percent slopes	17	24	31	46	22	38					1.5	2.2
Hecla fine sandy loam, 1 to 3 percent slopes	21	29	38	59	27	46	8.0	10.0	90	110	1.8	2.6
Hecla-Maddock sandy loams, 1 to 6 percent slopes	17	27	31	53	22	43	8.0	10.0	90	110	1.5	2.4
Hegne-Enloe silty clays [1]	26	35	47	73	34	56	10.0	12.5	95	120	2.3	3.1
Hegne-Fargo silty clays	28	38	51	77	36	61	10.5	13.5	105	130	2.4	3.3
Heimdal-Emrick loams, 3 to 6 percent slopes	26	35	47	73	34	56	10.0	12.5	110	140	2.3	3.1
Heimdal-Esmond loams, 6 to 9 percent slopes	15	21	27	44	21	34					1.1	1.7
LaDelle silty clay loam	35	45	63	95	46	72	13.0	17.0	150	190	3.0	4.0
Lamoure silt loam [1]	26	35	47	73	34	56					2.3	3.1
Lankin loam	33	43	60	90	43	69					2.9	3.8
La Prairie silt loam	35	45	63	95	46	72	13.0	17.0	150	190	3.0	4.0
Ludden silty clay [1]	23	32	41	64	30	51	8.5	11.0	95	120	1.9	2.7
Marsh												
Nahon silt loam	23	32	41	64	30	51	8.5	11.0	95	120	1.9	2.7
Nutley silty clay, 1 to 3 percent slopes	28	38	51	77	36	61	10.5	13.5	120	150	2.4	3.3
Nutley silty clay, 3 to 6 percent slopes	27	36	49	75	35	58	10.0	13.0	115	145	2.3	3.2
Nutley silty clay, 6 to 9 percent slopes	21	29	38	59	27	46	8.0	10.0	90	110	1.8	2.6
Nutley silty clay, 9 to 15 percent slopes	14	20	25	37	18	32					1.2	1.8
Nutley silty clay, 15 to 25 percent slopes												
Ojata silty clay loam											.5	.7
Overly silty clay loam	35	45	63	95	46	72	13.0	17.0	150	190	3.0	4.0
Overly-Fargo complex	33	43	60	90	43	69	12.5	16.0	140	180	2.9	3.8
Overly-Great Bend silty clay loams, 3 to 6 percent slopes	33	43	60	90	43	69	12.5	16.0	140	180	2.9	3.8
Perella silt loam [1]	26	35	47	73	34	56	10.0	12.5	110	140	2.3	3.1
Playmoor silty clay loam [1]	15	21	27	44	20	34					1.3	2.0
Renshaw loam, 1 to 3 percent slopes	15	21	27	44	20	34					1.3	1.9
Rockwell fine sandy loam [1]	17	24	31	46	22	38	8.0	10.0	90	110	1.5	2.2
Serden-Maddock loamy sands, 1 to 6 percent slopes											.7	1.2
Sioux-Arvilla complex, 1 to 6 percent slopes											.7	1.5

TABLE 2.—*Predicted average yields per acre of principal crops*—Continued

Soil	Wheat		Oats		Barley		Sugar beets		Potatoes		Hay	
	A	B	A	B	A	B	A	B	A	B	A	B
	Bu	*Bu*	*Bu*	*Bu*	*Bu*	*Bu*	*Tons*	*Tons*	*Cwt*	*Cwt*	*Tons*	*Tons*
Swenoda fine sandy loam	26	35	47	77	34	56	10.0	12.0	110	140	2.3	3.1
Swenoda loam	29	39	52	80	37	62	10.5	14.0	125	155	2.5	3.4
Tiffany loam [1]	23	32	41	64	30	51	8.5	11.0	95	120	1.9	2.7
Tonka silt loam [1]	26	35	47	73	34	56	----	----	----	----	2.3	3.1
Towner sandy loam, 1 to 3 percent slopes	23	32	41	64	30	51	8.5	11.0	95	120	1.9	2.7
Ulen fine sandy loam	21	29	38	59	27	46	8.0	10.0	90	110	1.8	2.6
Vallers-Doran clay loams [1]	24	33	43	73	31	53	----	----	----	----	2.1	2.9
Viking clay	28	38	51	77	36	61	----	----	----	----	2.4	3.3
Wahpeton silty clay, 1 to 3 percent slopes	33	43	60	90	43	69	12.5	16.0	110	140	2.9	3.8
Wheatville silt loam	31	41	56	88	41	66	11.5	15.0	135	170	2.7	3.6
Wyndmere fine sandy loam	23	32	42	68	30	52	8.5	11.5	100	125	2.0	2.8
Wyndmere loam	26	35	47	77	34	56	10.0	12.5	110	140	2.3	3.1
Wyndmere loam, saline	17	24	31	46	22	38	----	----	----	----	1.5	2.2
Wyndmere-Tiffany fine sandy loams [1]	24	33	43	70	31	53	9.0	12.0	105	130	2.1	2.9
Zell silt loam, 9 to 25 percent slopes	----	----	----	----	----	----	----	----	----	----	.7	1.5

[1] Yields are for drained areas.
[2] Too variable to be rated.

***Figure 17.*—A field windbreak of green ash and lilac planted alternately on Bearden silty clay loam protects the soil from blowing. Another windbreak in the background protects a farmstead from winter winds.**

TABLE 3.—*Height of trees and shrubs by windbreak suitability groups*

[Height is expressed in feet for trees and shrubs at 20 years of age. Windbreak suitability groups 9 and 10 are not listed in the table because they are not suited to trees and shrubs. See text for more information about those groups]

Trees and shrubs	Windbreak suitability group—							
	1	2	3	4	5	6	7	8
Eastern cottonwood	40–48	38–45	[1] NS	[1] NS	[1] NS	[1] NS	[1] NS	[1] NS
Northwest poplar	40–45	40–45	NS	NS	NS	NS	NS	NS
Dropmore elm	28–35	28–32	26–32	22–26	20–25	17–22	14–18	14–18
Siberian elm	28–35	28–32	26–32	22–26	20–25	17–22	14–18	14–18
Golden willow	28–33	28–33	NS	NS	NS	NS	NS	NS
White willow	28–33	28–33	NS	NS	NS	NS	NS	NS
Green ash	21–26	21–26	20–25	16–20	15–19	14–18	NS	14–18
Ponderosa pine	18–22	20–22	18–22	17–19	15–20	14–18	12–15	11–14
Scotch pine	18–22	20–22	18–22	17–19	NS	NS	NS	NS
Bur oak	18–20	18–20	17–19	15–17	16–18	NS	NS	NS
Manchurian crabapple	18–20	16–18	15–17	13–15	15–17	12–14	NS	NS
Siberian crabapple	18–20	16–18	15–17	13–15	15–17	12–14	NS	NS
Black Hills spruce	16–20	15–18	15–18	15–18	NS	NS	NS	NS
Colorado blue spruce	16–20	15–18	15–18	15–18	NS	NS	NS	NS
Russian-olive	15–19	15–19	14–18	12–15	11–14	11–14	NS	11–14
Harbin pear	18–22	18–20	14–16	11–13	11–13	11–12	NS	NS
Common chokecherry	11–14	9–11	10–12	8–10	8–10	7–9	NS	NS
Eastern redcedar	11–13	11–13	12–15	10–12	9–11	8–10	7–9	7–9
Rocky Mountain juniper	11–13	11–13	12–15	10–12	9–11	8–10	7–9	7–9
Caragana	9–11	7–9	8–10	6–8	8–10	7–9	5–7	5–7
Amur maple	9–11	8–10	7–9	NS	NS	NS	NS	NS
Buffaloberry	8–10	6–8	7–9	7–9	6–8	5–6	NS	4–5
Honeysuckle	8–10	7–9	8–10	6–8	7–9	6–8	NS	5–7
Late Villosa lilac	8–9	6–7	6–7	NS	NS	NS	NS	NS
Common lilac	7–8	5–6	6–7	4–5	6–7	4–5	NS	5–6
Redosier dogwood	7–8	6–7	5–7	NS	NS	NS	NS	NS
Cotoneaster	6–7	5–6	5–6	6–7	6–7	NS	NS	5–6
Nanking cherry [2]	5–7	6–8	5–6	4–5	4–5	6–7	NS	NS
American plum	7–11	6–9	8–12	6–9	7–9	6–9	NS	NS
Juneberry	5–6	5–6	5–6	NS	NS	NS	NS	NS
Golden currant	4–5	4–5	4–5	3–5	3–5	3–5	NS	NS
Western Sandcherry [3]	4–5	NS	3–4	NS	4–5	NS	NS	NS

[1] NS means not suited.
[2] Generally has a serious decline in vigor within 10 years.
[3] Generally has a serious decline in vigor after 5 years.

percent, severe to very severe if 9 to 12 percent, and very severe if 12 percent or more.

Conserving water is most important on soils that have slopes of more than 6 percent. Special site preparation, planting, and cultivation practices are needed to successfully establish and maintain plantings if soil blowing and water erosion are hazards. The water table is beyond the reach of tree roots in all soils in groups 3 through 10, except for several soils in group 10 that are too wet for most trees and shrubs.

Table 3 lists most trees and shrubs used in windbreak plantings and gives the actual or estimated average height at 20 years of age.

WINDBREAK SUITABILITY GROUP 1

In this group are the deep, well drained to poorly drained, sandy to clayey soils of the Bearden, Beotia, Bohnsack, Cashel, Divide, Doran, Embden, Emrick, Fairdale, Fargo, Galchutt, Gardena, Gilby, Glyndon, Hamerly, Hecla, Hegne, LaDelle, Lankin, La Prairie, Overly, Swenoda, Towner, Ulen, Viking, Wahpeton, Wheatville, and Wyndmere series. In all but Beotia, Emrick, Fairdale, Gardena, LaDelle, Lankin, La Prairie, Towner, and Wahpeton soils, the water table is within the reach of tree roots. The susceptibility to soil blowing ranges from slight to very severe, and the susceptibility to water erosion ranges from slight to severe.

These soils are well suited to windbreaks and other kinds of woody plantings. They have good potential for all climatically adapted trees and shrubs. There are no critical limitations to the use of these soils for woody plants.

WINDBREAK SUITABILITY GROUP 2

In this group are the deep, somewhat poorly drained to very poorly drained, sandy to clayey soils of the Arveson, Borup, Colvin, Dovray, Enloe, Grano, Hamar, Lamoure, Lindaas, Perella, Rockwell, Tiffany, Tonka, and Vallers series. In some areas the Arveson, Borup, Colvin, Grano, Lamoure, Rockwell, and Vallers soils have a slightly saline subsoil and underlying material. All the soils are in low areas where they receive runoff from surrounding areas or where the high water table is in the root zone. Most of the soils receive extra moisture from both of these sources. If not drained, the soils are excessively wet or ponded in spring or during periods of flooding. The susceptibility to soil

blowing ranges from slight to severe, but the susceptibility to water erosion is slight.

If drained, the soils are well suited to windbreaks and other kinds of woody plantings, but in areas where the subsoil and underlying material is slightly saline, only salt-tolerant trees and shrubs should be planted. These soils have good potential for all climatically adapted trees and shrubs. Where artificial drainage has been installed and where salinity is not a problem, there are no critical limitations to the use of these soils for woody plants.

WINDBREAK SUITABILITY GROUP 3

In this group are the deep, well drained and moderately well drained, loamy soils of the Eckman, Gardena, Great Bend and Heimdal series. The susceptibility to soil blowing is slight or moderate, and the susceptibility to water erosion ranges from moderate through very severe.

The soils are well suited to windbreaks and other kinds of woody plantings. They have good potential for all climatically adapted trees and shrubs, except those that have a high moisture requirement. There are no critical limitations to the use of these soils for woody plants.

WINDBREAK SUITABILITY GROUP 4

In this group is the deep, well drained, clayey Nutley soil. This soil has a compact, clayey subsoil that restricts the growth of roots and the downward movement of water. The susceptibility to soil blowing is moderate, and the susceptibility to water erosion ranges from slight through very severe.

The soil is moderately well suited to windbreaks and other kinds of woody plantings. It has good potential for most of the climatically adapted trees and shrubs. There are no critical limitations to the use of this soil for woody plants.

WINDBREAK SUITABILITY GROUP 5

In this group are the deep, well drained, loamy and sandy Egeland and Maddock series. The susceptibility to soil blowing ranges from moderate through very severe, and the susceptibility to water erosion ranges from slight to severe.

The soils are well suited to windbreaks and other kinds of woody plantings. They have good potential for most of the climatically adapted trees and shrubs, except those that have a high moisture requirement. There are no critical limitations for woody plants.

WINDBREAK SUITABILITY GROUP 6

In this group are the somewhat excessively drained, loamy soils of the Arvilla and Renshaw series. These soils are shallow to moderately deep to sand and gravel. The susceptibility to soil blowing is slight to severe, and the susceptibility to water erosion is moderate or severe.

The soils are poorly suited to windbreaks and other kinds of woody plantings. There are no trees and shrubs that grow well. It is possible to establish plantings by properly selecting climatically adapted trees and shrubs, but optimum survival, growth, and vigor should not be required or expected. Field windbreaks should not be planted. The critical limitation to the use of these soils for woody plants is the low available water capacity in the underlying sand and gravel.

WINDBREAK SUITABILITY GROUP 7

In this group is the deep, excessively drained, sandy Serden soil. The susceptibility to soil blowing is very severe, but the susceptibility to water erosion is slight or moderate.

The soil is poorly suited to windbreaks and other kinds of woody plantings. There are no trees and shrubs that grow well. It is possible to establish plantings, but optimum survival, growth, and vigor should not be required or expected. Field windbreaks should not be planted. The critical limitation to the use of this soil for woody plants is the low available water capacity.

WINDBREAK SUITABILITY GROUP 8

In this group are the deep, well drained and somewhat excessively drained, loamy soils of the Esmond and Zell series. The susceptibility to soil blowing is severe, and the susceptibility to water erosion is severe or very severe.

The soils in this group are moderately well suited to windbreaks and other kinds of woody plantings. It is possible to establish plantings by properly selecting climatically adapted trees and shrubs, but optimum survival, growth, and vigor should not be required or expected. The critical limitations to the use of these soils for woody plants are the rapid runoff, a restricted rooting zone, and the high lime content.

WINDBREAK SUITABILITY GROUP 9

In this group are the deep, somewhat poorly drained and poorly drained, loamy or clayey soils of the Nahon and Ryan series. These soils have a dense claypan subsoil and contain a large amount of soluble salts. The susceptibility to soil blowing is slight or moderate, and the susceptibility to water erosion is slight.

The soils are not suited to any kind of woody planting. The growth potential is very poor for all climatically adapted trees and shrubs. Windbreaks and other kinds of woody plantings should not be attempted. The critical limitations to the use of these soils for woody plants are the restricted rooting zone and the high concentration of soluble salts.

WINDBREAK SUITABILITY GROUP 10

In this group are soils of the Bearden, Borup, Colvin, Gilby, Glyndon, Hamerly, Ludden, Nutley, Ojata, Playmoor, Sioux, and Wyndmere series. These soils have a wide range of depth, texture, drainage, available water capacity, permeability, and slope. Included are soils that are too waterlogged, too low in available water capacity, and too shallow, sodic, saline, or steep, as well as too restrictive in rooting depth or erodible.

The soils are unsuited to windbreaks. Scalp plantings or specialized plantings for wildlife habitat, recreation, or beautification can be made on the Nutley soils, but it is important to select the most favorable sites and to plant those trees and shrubs that have the best potential to survive and grow. The other soils are unsuited to any kind of woody planting. All of these soils have one or more critical limitation for planting, survival, vigor, and growth of trees and shrubs.

Wildlife Habitat[3]

Fish and wildlife in the county have been substantially reduced since the county was settled. The composition of the bird population is similar because a wide variety of habitats remain, but the number is much reduced. Wild geese and sandhill crane have been replaced to some degree by farm birds such as ring-necked pheasant and gray partridge, but even the number of these is much reduced.

Mammals, such as elk, moose, antelope, and bear, have been exterminated and have not been replaced by other wild animals.

In addition, a wide range of habitats is still available to more than 100 other kinds of birds.

In the county there are cottontail rabbits, tree squirrels, ducks, geese, and white-tailed deer and mourning dove. Small numbers of gray partridge, ring-necked pheasant, and sharp-tailed grouse also inhabit the county. The red fox, jackrabbit, mink, muskrat, and raccoon are important furbearers.

A few private ponds in the county are suitable for fisheries, and the potential for building and managing additional private ponds is fair. The most common fish are perch, bullheads, northern pike, walleye, and catfish.

Most wildlife habitats are created, improved, or maintained by managing existing vegetation, planting suitable vegetation, inducing natural establishment of desired plants, by moving earth to improve conditions, or by using a combination of these measures.

In table 4, the soils in Traill County are rated for three kinds of wildlife, based on the ability of the soil to produce the various habitat elements needed for wildlife.

Openland wildlife includes gray partridge, pheasant, cottontail rabbit, horned lark, red fox, and goldfinch. The habitat elements for openland wildlife are grain and seed crops, domestic grasses and legumes, wild herbaceous plants, and shrubs.

Rangeland wildlife includes white-tailed deer, sharp-tailed grouse, chestnut-collared longspur, jackrabbit, and other animals. The habitat elements for rangeland wildlife are wild herbaceous plants and shrubs.

Wetland wildlife includes animals, such as ducks, herons, shorebirds, mink, muskrat, and coot, that live in natural wetlands. The habitat elements for wetland wildlife are wetland plants and shallow-water areas.

Interpretations were not made for woodland wildlife, although there is natural woodland in the county. Locally, these wooded tracts provide habitat for birds and mammals, such as thrushes, warblers, vireos, and tree squirrels.

The present land use, the relationship of one soil to another, and the size, shape, or extent of the soil areas are not considered in making the interpretations. The mobility of wildlife is not considered so that the criteria apply only to the suitability of each mapping unit for wildlife habitat.

These ratings should be used as an aid in selecting sites for general kinds of wildlife habitat, in determining the suitability of the soil for the kind of habitat needed, or in deciding the management intensity needed to produce satisfactory results. The ratings provide a means of grouping soils for broad-scale wildlife planning or aiding landowners in selecting management practices for desired wildlife.

For information on the suitability of soils for impoundments, such as fish ponds or wetland developments, see table 7 in the section "Engineering Uses of the Soils."

[3] By ERLING B. PODOLL, biologist, Soil Conservation Service, Bismarck.

Recreation Facilities[4]

Traill County has facilities for outdoor games and playground activities. These facilities and limited picnic and camping facilities are provided at the four city parks and Augustadt Dam.

Table 5 gives the degree and kind of limitation that affects the use of soils for playgrounds, campsites, picnic areas, and paths and trails. The degree of limitation is expressed as slight, moderate, severe, and very severe. *Slight* means that the soil properties are generally favorable and limitations are so minor that they can easily be overcome. *Moderate* means that the limitations can be overcome or modified by planning, by design, or by special maintenance. *Severe* or *very severe* means that costly soil reclamation, special design, intensive maintenance, or a combination of these is required to overcome the limitations.

Playgrounds are used intensively for baseball, football, badminton, and similar organized games. Soils suited to this use must be able to withstand intensive foot traffic. The best soils are nearly level and free of coarse fragments and rock outcrops. They have good drainage, freedom from flooding during periods of heavy use, and a surface that is firm after rain but not dusty when dry.

Campsites are used intensively for tents and small camp trailers and the accompanying activities of outdoor living. Little preparation of the site is required other than shaping and leveling for parking areas. Camp areas are subject to heavy foot traffic and limited vehicle use. The best soils have mild slopes, good drainage, a surface free of rocks or coarse fragments, freedom from flooding during periods of heavy use, and a surface that is firm after rain but not dusty when dry.

Picnic areas are attractive, natural or landscaped tracts that are subject to heavy foot traffic. Most vehicle traffic, however, is confined to access roads. The best soils for picnic areas are firm when wet but not dusty when dry, are free of flooding during the season of use, and do not have slopes or stoniness that generally increase the cost of leveling sites or of building access roads.

Paths and trails are used for local and cross-country travel by foot or horseback. Design and layout should require little or no cutting and filling. The best soils are at least moderately well drained, are firm when wet but not dusty when dry, are flooded not more than once during the season of use, have slopes of less than 15 percent, and are free of rocks or stones on the surface.

It is important that a good cover of vegetation be established and maintained. The soil suitability for

[4] By ERLING B. PODOLL, biologist, Soil Conservation Service, Bismarck.

TABLE 4.—*Suitability of the soils for kinds of wildlife*

Soil	Openland wildlife	Rangeland wildlife	Wetland wildlife
Arveson fine sandy loam	Fair	Fair	Good.
Arveson loam	Good	Fair	Good.
Arvilla sandy loam, 1 to 6 percent slopes	Fair	Poor	Very poor.
Bearden silt loam, saline	Fair	Poor	Fair.
Bearden silty clay loam	Good	Fair	Fair.
Bearden silty clay loam, clay substratum	Good	Fair	Fair.
Bearden-Lindaas silty clay loams:			
Bearden part	Good	Fair	Fair.
Lindaas part	Good	Fair	Good.
Bearden-Overly silty clay loams:			
Bearden part	Good	Fair	Fair.
Overly part	Good	Fair	Poor.
Bearden-Perella silty clay loams:			
Bearden part	Good	Fair	Fair.
Perella part	Good	Fair	Good.
Bearden and Glyndon silt loams	Good	Fair	Fair.
Beotia silt loam	Good	Fair	Very poor.
Bohnsack loam	Good	Fair	Fair.
Bohnsack-Tiffany loams:			
Bohnsack part	Good	Fair	Fair.
Tiffany part	Good	Fair	Good.
Borup silt loam	Fair	Fair	Good.
Borup silt loam, saline	Fair	Poor	Good.
Cashel silty clay, 1 to 3 percent slopes	Good	Fair	Fair.
Cashel silty clay, channeled	Poor	Fair	Very poor.
Colvin silt loam	Good	Fair	Good.
Colvin silt loam, saline	Fair	Poor	Good.
Cut and fill land.			
Too variable for reliable interpretation.			
Divide loam	Good	Fair	Poor.
Doran clay loam	Good	Fair	Fair.
Dovray silty clay	Fair	Poor	Good.
Egeland loam, 1 to 3 percent slopes	Good	Fair	Very poor.
Egeland-Embden fine sandy loams, 1 to 3 percent slopes:			
Egeland part	Good	Fair	Very poor.
Embden part	Good	Fair	Poor.
Egeland-Embden fine sandy loams, 3 to 6 percent slopes	Good	Fair	Very poor.
Embden fine sandy loam	Good	Fair	Poor.
Embden very fine sandy loam	Good	Fair	Poor.
Emrick loam	Good	Fair	Poor.
Emrick-Heimdal loams, 1 to 3 percent slopes:			
Emrick part	Good	Fair	Poor.
Heimdal part	Good	Fair	Very poor.
Fairdale silt loam, 1 to 3 percent slopes	Good	Fair	Poor.
Fargo silty clay loam	Fair	Poor	Fair.
Fargo silty clay	Fair	Poor	Fair.
Fargo-Dovray silty clays:			
Fargo part	Fair	Poor	Fair.
Dovray part	Fair	Poor	Good.
Fargo-Enloe silty clay loams:			
Fargo part	Fair	Poor	Fair.
Enloe part	Good	Fair	Good.
Fargo-Enloe silty clays:			
Fargo part	Fair	Poor	Fair.
Enloe part	Good	Fair	Good.
Fargo-Hegne silty clays	Fair	Poor	Fair.
Fargo-Ryan silty clays:			
Fargo part	Fair	Poor	Fair.
Ryan part	Poor	Very poor	Fair.
Galchutt-Fargo complex:			
Galchutt part	Good	Fair	Fair.
Fargo part	Fair	Poor	Fair.
Gardena silt loam	Good	Fair	Poor.
Gardena-Eckman silt loams, 3 to 6 percent slopes	Good	Fair	Very poor.
Gardena-Zell silt loams, 6 to 9 percent slopes	Good	Fair	Very poor.
Gilby loam	Good	Fair	Fair.
Gilby-Tonka complex:			
Gilby part	Good	Fair	Fair.
Tonka part	Good	Fair	Good.
Gilby-Tonka complex, saline:			
Gilby part	Fair	Poor	Fair.
Tonka part	Good	Fair	Good.
Glyndon silt loam	Good	Fair	Fair.
Glyndon silt loam, saline	Fair	Poor	Fair.

TABLE 4.—*Suitability of the soils for kinds of wildlife*—Continued

Soil	Openland wildlife	Rangeland wildlife	Wetland wildlife
Glyndon-Perella silt loams:			
Glyndon part	Good	Fair	Fair.
Perella part	Good	Fair	Good.
Glyndon-Tiffany loams:			
Glyndon part	Good	Fair	Fair.
Tiffany part	Fair	Fair	Fair.
Grano silty clay	Fair	Poor	Good.
Great Bend silty clay loam, 1 to 3 percent slopes	Good	Fair	Very poor.
Great Bend silty clay loam, 6 to 9 percent slopes	Good	Fair	Very poor.
Great Bend silty clay loam, 9 to 15 percent slopes	Good	Fair	Very poor.
Hamar loamy fine sand	Fair	Fair	Fair.
Hamerly-Tonka clay loams:			
Hamerly part	Good	Fair	Fair.
Tonka part	Good	Fair	Good.
Hamerly-Tonka clay loams, saline:			
Hamerly part	Fair	Poor	Fair.
Tonka part	Good	Fair	Good.
Hecla loamy fine sand, 1 to 3 percent slopes	Good	Fair	Very poor.
Hecla fine sandy loam, 1 to 3 percent slopes	Good	Fair	Very poor.
Hecla-Maddock sandy loams, 1 to 6 percent slopes	Good	Fair	Very poor.
Hegne-Enloe silty clays:			
Hegne part	Fair	Poor	Fair.
Enloe part	Good	Fair	Good.
Hegne-Fargo silty clays	Fair	Poor	Fair.
Heimdal-Emrick loams, 3 to 6 percent slopes	Good	Fair	Very poor.
Heimdal-Esmond loams, 6 to 9 percent slopes	Good	Fair	Very poor.
LaDelle silty clay loam	Good	Good	Poor.
Lamoure silt loam	Good	Fair	Good.
Lankin loam	Good	Fair	Poor.
La Prairie silt loam	Good	Good	Poor.
Ludden silty clay	Fair	Poor	Fair.
Marsh	Very poor	Very poor	Good.
Nahon silt loam	Fair	Poor	Fair.
Nutley silty clay, 1 to 3 percent slopes	Fair	Poor	Very poor.
Nutley silty clay, 3 to 6 percent slopes	Fair	Poor	Very poor.
Nutley silty clay, 6 to 9 percent slopes	Fair	Poor	Very poor.
Nutley silty clay, 9 to 15 percent slopes	Fair	Poor	Very poor.
Nutley silty clay, 15 to 25 percent slopes	Fair	Poor	Very poor.
Ojata silty clay loam	Poor	Very poor	Good.
Overly silty clay loam	Good	Fair	Poor.
Overly-Fargo complex:			
Overly part	Good	Fair	Poor.
Fargo part	Fair	Poor	Fair.
Overly-Great Bend silty clay loams, 3 to 6 percent slopes	Good	Fair	Very poor.
Perella silt loam	Good	Fair	Good.
Playmoor silty clay loam	Fair	Fair	Good.
Renshaw loam, 1 to 3 percent slopes	Fair	Poor	Very poor.
Rockwell fine sandy loam	Fair	Fair	Fair.
Serden-Maddock loamy sands, 1 to 6 percent slopes:			
Serden part	Poor	Fair	Very poor.
Maddock part	Good	Fair	Very poor.
Sioux-Arvilla complex, 1 to 6 percent slopes:			
Sioux part	Poor	Poor	Very poor.
Arvilla part	Fair	Poor	Very poor.
Swenoda fine sandy loam	Good	Fair	Poor.
Swenoda loam	Good	Fair	Poor.
Tiffany loam	Good	Fair	Fair.
Tonka silt loam	Good	Fair	Good.
Towner sandy loam, 1 to 3 percent slopes	Good	Fair	Poor.
Ulen fine sandy loam	Good	Fair	Fair.
Vallers-Doran clay cloams:			
Vallers part	Good	Fair	Good.
Doran part	Good	Fair	Fair.
Viking clay	Fair	Poor	Fair.
Wahpeton silty clay, 1 to 3 percent slopes	Fair	Poor	Poor.
Wheatville silt loam	Good	Fair	Poor.
Wyndmere fine sandy loam	Good	Fair	Poor.
Wyndmere loam	Good	Fair	Fair.
Wyndmere loam, saline	Fair	Poor	Fair.
Wyndmere-Tiffany fine sandy loams:			
Wyndmere part	Good	Fair	Poor.
Tiffany part	Fair	Fair	Fair.
Zell silt loam, 9 to 25 percent slopes	Fair	Fair	Very poor.

TABLE 5.—*Degree and kind of limitation of the soils for recreation facilities*

Soil series and map symbols	Playgrounds	Campsites	Picnic areas	Paths and trails
Arveson: Ar, As	Severe: poorly drained; high water table.	Severe: poorly drained; high water table.	Severe: poorly drained; high water table.	Severe: poorly drained.
Arvilla: AvB	Slight where slopes are 1 to 3 percent. Moderate where slopes are 3 to 6 percent.	Slight	Slight	Slight.
Bearden:				
Ba, Bs	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	None to slight	None to slight.
Be, Bg	Moderate: silty clay loam surface layer; somewhat poorly drained.	Moderate: silty clay loam surface layer; somewhat poorly drained.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.
Bn:				
Bearden part	Moderate: silty clay loam surface layer; somewhat poorly drained.	Moderate: silty clay loam surface layer; somewhat poorly drained.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.
Lindaas part	Severe: poorly drained	Severe: poorly drained	Severe: poorly drained	Severe: poorly drained.
Bo:				
Bearden part	Moderate: silty clay loam surface layer; somewhat poorly drained.	Moderate: somewhat poorly drained; silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.
Overly part	Moderate: moderately slow permeability; silty clay loam surface layer.	Moderate: silty clay loam surface layer; moderately slow permeability.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.
Bp:				
Bearden part	Moderate: silty clay loam surface layer; somewhat poorly drained.	Moderate: silty clay loam surface layer; somewhat poorly drained.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.
Perella part	Severe: poorly drained	Severe: poorly drained	Severe: poorly drained	Severe: poorly drained.
Beotia: Bt	None to slight	None to slight	None to slight	None to slight.
Bohnsack:				
Bu	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Bv:				
Bohnsack part	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Tiffany part	Severe: poorly drained	Severe: poorly drained	Severe: poorly drained	Severe: poorly drained.
Borup: Bw, Bx	Severe: poorly drained; high water table.	Severe: poorly drained; high water table.	Severe: poorly drained; high water table.	Severe: poorly drained.
Cashel: CaA, CaC	Severe: silty clay surface layer; flooding.	Severe: silty clay surface layer; flooding.	Severe: silty clay surface layer; flooding.	Severe: silty clay surface layer.
Colvin: Co, Cs	Severe: poorly drained; high water table.	Severe: poorly drained; high water table.	Severe: poorly drained; high water table.	Severe: poorly drained.
Cut and fill land: Cu. Properties too variable for reliable interpretations.				
Divide: Dd	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.

TABLE 5.— *Degree and kind of limitation of the soils for recreation facilities*—Continued

Soil series and map symbols	Playgrounds	Campsites	Picnic areas	Paths and trails
Doran: Do	Moderate: clay loam surface layer; somewhat poorly drained.	Moderate: clay loam surface layer; somewhat poorly drained.	Moderate: clay loam surface layer; somewhat poorly drained.	Moderate: clay loam surface layer.
Dovray: Dv	Severe: very poorly drained; ponding.	Severe: very poorly drained; ponding.	Severe: very poorly drained; ponding.	Severe: very poorly drained; silty clay surface layer.
Egeland:				
EdA, EgA	None to slight	None to slight	None to slight	None to slight.
EgB	Moderate: slope	None to slight	None to slight	None to slight.
Embden: Em, En	None to slight	None to slight	None to slight	None to slight.
Emrick: Eo, EpA	None to slight	None to slight	None to slight	None to slight.
Fairdale: FaA	Moderate to severe: flooding.	Moderate to severe: flooding.	Moderate to severe: flooding.	None to slight.
Fargo:				
Fb	Severe: poorly drained	Severe: poorly drained	Severe: poorly drained	Severe: poorly drained.
Fc	Severe: silty clay surface layer; poorly drained.	Severe: silty clay surface layer; poorly drained.	Severe: silty clay surface layer; poorly drained.	Severe: silty clay surface layer; poorly drained.
Fd, Fg	Severe: poorly drained; ponding.	Severe: poorly drained; ponding.	Severe: poorly drained; ponding.	Severe: poorly drained; silty clay surface layer.
Fe:				
Fargo part	Severe: poorly drained	Severe: poorly drained	Severe: poorly drained	Severe: poorly drained.
Enloe part	Severe: poorly drained; ponding.	Severe: poorly drained; ponding.	Severe: poorly drained; ponding.	Severe: poorly drained.
Fh	Severe: poorly drained; silty clay surface layer.	Severe: poorly drained; silty clay surface layer.	Severe: poorly drained; silty clay surface layer.	Severe: poorly drained; silty clay surface layer.
Fn:				
Fargo part	Severe: poorly drained; silty clay surface layer.	Severe: poorly drained; silty clay surface layer.	Severe: poorly drained; silty clay surface layer.	Severe: poorly drained; silty clay surface layer.
Ryan part	Severe: poorly drained; very slow permeability.	Severe: poorly drained; very slow permeability.	Severe: poorly drained; silty clay surface layer.	Severe: poorly drained; silty clay surface layer.
Galchutt: Ga:				
Galchutt part	Moderate: slow permeability; somewhat poorly drained.	Moderate: slow permeability; somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Fargo part	Severe: poorly drained	Severe: poorly drained	Severe: poorly drained	Severe: poorly drained.
Gardena:				
Gd	None to slight	None to slight	None to slight	None to slight.
GeB	Moderate: slope	None to slight	None to slight	None to slight.
GfC	Severe: slope	None to slight	None to slight	None to slight.
Gilby:				
Gg	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Gh, Gk:				
Gilby part	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Tonka part	Severe: poorly drained; ponding.	Severe: poorly drained; ponding.	Severe: poorly drained; ponding.	Severe: poorly drained.
Glyndon:				
Gm, Gn	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	None to slight	None to slight.
Go:				
Glyndon part	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	None to slight	None to slight.
Perella part	Severe: poorly drained; ponding.	Severe: poorly drained; ponding.	Severe: poorly drained; ponding.	Severe: poorly drained.

TABLE 5.— *Degree and kind of limitation of the soils for recreation facilities*—Continued

Soil series and map symbols	Playgrounds	Campsites	Picnic areas	Paths and trails
Glyndon—Continued				
Gr:				
Glyndon part	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	None to slight	None to slight.
Tiffany part	Severe: poorly drained	Severe: poorly drained	Severe: poorly drained	Severe: poorly drained.
Grano: Gs	Severe: very poorly drained; ponding.	Severe: very poorly drained; ponding.	Severe: very poorly drained; ponding.	Severe: very poorly drained; ponding.
Great Bend:				
GwA	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.
GwC	Severe: slope	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.
GwD	Severe: slope	Moderate: silty clay loam surface layer; slope.	Moderate: silty clay loam surface layer; slope.	Moderate: silty clay loam surface layer.
Hamar: Ha	Severe: poorly drained; high water table.	Severe: poorly drained; high water table.	Severe: poorly drained; high water table.	Severe: poorly drained.
Hamerly: Hb, Hc:				
Hamerly part	Moderate: somewhat poorly drained; clay loam surface layer.	Moderate: somewhat poorly drained; clay loam surface layer.	Moderate: somewhat poorly drained; clay loam surface layer.	Moderate: somewhat poorly drained; clay loam surface layer.
Tonka part	Severe: poorly drained; ponding.	Severe: poorly drained; ponding.	Severe: poorly drained; ponding.	Severe: poorly drained.
Hecla:				
HeA	Moderate: loamy fine sand surface layer.	Moderate: loamy fine sand surface layer.	Moderate: loamy fine sand surface layer.	Moderate: loamy fine sand surface layer.
HfA, HmB	None to slight. For HmB, moderate where slopes are 3 to 6 percent.	None to slight	None to slight	None to slight.
Hegne:				
Hn:				
Hegne part	Severe: silty clay surface layer; poorly drained.	Severe: silty clay surface layer; poorly drained.	Severe: silty clay surface layer; poorly drained.	Severe: silty clay surface layer; poorly drained.
Enloe part	Severe: poorly drained; ponding.	Severe: poorly drained; ponding.	Severe: poorly drained; ponding.	Severe: poorly drained; silty clay surface layer.
Ho	Severe: poorly drained; silty clay surface layer.	Severe: poorly drained; silty clay surface layer.	Severe: poorly drained; silty clay surface layer.	Severe: poorly drained; silty clay surface layer.
Heimdal:				
HrB	Moderate: slope	None to slight	None to slight	None to slight.
HsC	Severe: slope	None to slight	None to slight	None to slight.
LaDelle: La	Severe: flooding	Severe: flooding	Moderate: flooding; silty clay loam surface layer.	Moderate: silty clay loam surface layer; flooding.
Lamoure: Lm	Severe: poorly drained; flooding.	Severe: poorly drained; flooding.	Severe: poorly drained; flooding.	Severe: poorly drained.
Lankin: Ln	None to slight	None to slight	None to slight	None to slight.
La Prairie: Lp	Moderate to severe: flooding.	Moderate to severe: flooding.	Slight to moderate: flooding.	Slight: flooding.
Ludden: Lu	Severe: poorly drained; flooding.	Severe: poorly drained; flooding.	Severe: poorly drained; flooding.	Severe: poorly drained; flooding.
Marsh: Ma	Very severe: high water table; ponding.	Very severe: high water table; ponding.	Very severe: high water table; ponding.	Very severe: high water table; ponding.
Nahon: Na	Severe: very slow permeability.	Severe: very slow permeability.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.

TABLE 5.—*Degree and kind of limitation of the soils for recreation facilities*—Continued

Soil series and map symbols	Playgrounds	Campsites	Picnic areas	Paths and trails
Nutley:				
NuA, NuB	Severe: silty clay surface layer.	Severe: silty clay surface layer.	Severe: silty clay surface layer.	Severe: silty clay surface layer.
NuC, NuD	Severe: slope; silty clay surface layer.	Severe: silty clay surface layer.	Severe: silty clay surface layer.	Severe: silty clay surface layer.
NuE	Severe: slope; silty clay surface layer.	Severe: slope; silty clay surface layer.	Severe: slope; silty clay surface layer.	Severe: silty clay surface layer.
Ojata: Oa	Severe: poorly drained	Severe: poorly drained	Severe: poorly drained	Severe: poorly drained.
Overly:				
Or	Moderate: moderately slow permeability; silty clay loam surface layer.	Moderate: moderately slow permeability; silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.
Os:				
Overly part	Moderate: moderately slow permeability; silty clay loam surface layer.	Moderate: moderately slow permeability; silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.
Fargo part	Severe: silty clay surface layer; poorly drained.	Severe: silty clay surface layer; poorly drained.	Severe: silty clay surface layer; poorly drained.	Severe: silty clay surface layer; poorly drained.
OvB	Moderate: slope; silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.
Perella: Pe	Severe: poorly drained; ponding.	Severe: poorly drained; ponding.	Severe: poorly drained; ponding.	Severe: poorly drained.
Playmoor: Pr	Severe: poorly drained; flooding.	Severe: poorly drained; flooding.	Severe: poorly drained; flooding.	Severe: poorly drained.
Renshaw: ReA	None to slight	None to slight	None to slight	None to slight.
Rockwell: Ro	Severe: poorly drained	Severe: poorly drained	Severe: poorly drained	Severe: poorly drained.
Serden: SmB	Severe: loamy sand surface layer.	Severe: loamy sand surface layer.	Severe: loamy sand surface layer.	Moderate: loamy sand surface layer.
Sioux: SrB	Slight to moderate: slope.	None to slight	None to slight	None to slight.
Swenoda: Sv, Sw	None to slight	None to slight	None to slight	None to slight.
Tiffany: Tf	Severe: poorly drained; ponding; high water table.	Severe: poorly drained; ponding; high water table.	Severe: poorly drained; ponding; high water table.	Severe: poorly drained.
Tonka: To	Severe: poorly drained; ponding.	Severe: poorly drained; ponding.	Severe: poorly drained; ponding.	Severe: poorly drained.
Towner: TrA	None to slight	None to slight	None to slight	None to slight.
Ulen: Un	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Vallers: Vd:				
Vallers part	Severe: poorly drained	Severe: poorly drained	Severe: poorly drained	Severe: poorly drained.
Doran part	Moderate: clay loam surface layer; somewhat poorly drained.	Moderate: clay loam surface layer; somewhat poorly drained.	Moderate: clay loam surface layer; somewhat poorly drained.	Moderate: clay loam surface layer.
Viking: Vk	Severe: poorly drained; clay surface layer.	Severe: poorly drained; clay surface layer.	Severe: poorly drained; clay surface layer.	Severe: poorly drained; clay surface layer.
Wahpeton: WaA	Severe: silty clay surface layer.	Severe: silty clay surface layer.	Severe: silty clay surface layer.	Severe: silty clay surface layer.
Wheatville: Wh	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	None to slight	None to slight.

TABLE 5.—*Degree and kind of limitation of the soils for recreation facilities*—Continued

Soil series and map symbols	Playgrounds	Campsites	Picnic areas	Paths and trails
Wyndmere:				
Wn, Wo, Ws	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	None to slight	None to slight.
Wt:				
Wyndmere part	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	None to slight	None to slight.
Tiffany part	Severe: poorly drained; high water table.	Severe: poorly drained; high water table.	Severe: poorly drained; high water table.	Severe: poorly drained.
Zell: ZeE	Severe: slope	Moderate to severe: slope.	Moderate to severe: slope.	Slight to moderate: slope.

growing and maintaining vegetation was not considered in the ratings, but it is an important factor to consider in final evaluation for such uses.

For related recreation facilities, such as interior roads, buildings, and sewage disposal systems, see table 7 in the section "Engineering Uses of the Soils."

Engineering Uses of the Soils [5]

This section is useful to planning commissions, town and city managers, land developers, engineers, contractors, farmers, and others who need information about soils used as structural material or as foundation on which structures are built.

Among properties of soils highly important in engineering are permeability, strength, compaction characteristics, drainage, shrink-swell potential, grain size, plasticity, and reaction. Also important are depth to the water table, depth to bedrock, and slope. These properties, in various degrees and combinations, affect construction and maintenance of roads, airports, pipelines, foundations for small buildings, irrigation systems, ponds and small dams, and systems for disposal of sewage and refuse.

Information in this section of the soil survey can be helpful to those who—

1. Select potential residential, industrial, commercial, and recreational areas.
2. Evaluate alternate routes for roads, highways, pipelines, and underground cables.
3. Seek sources of gravel, sand, or clay.
4. Plan farm drainage systems, irrigation systems, ponds, terraces, and other structures for controlling water and conserving soil.
5. Correlate performance of structures already built with properties of the soils on which they are built, to help predict performance of structures on the same or similar kinds of soil in other locations.
6. Predict the trafficability of soils for cross-country movement of vehicles and construction equipment.
7. Develop preliminary estimates pertinent to construction in a particular area.

Most of the information in this section is presented in tables. Table 6 shows estimated soil properties significant in engineering. Table 7 gives interpretations for various engineering uses.

This information, along with the soil map and data in other parts of this publication, can be used to make interpretations in addition to those given in tables 6 and 7, and it can also be used to make other useful maps.

This information, however, does not eliminate the need for further investigations at sites selected for engineering works, especially works that involve heavy loads or that require excavations to depths generally greater than 6 feet. Also, inspection of sites, especially the small ones, is needed because many delineated areas of a given soil can include small areas of other kinds of soil that have strongly contrasting properties and different suitability or limitations for soil engineering.

Some of the terms used in this soil survey have special meaning to soil scientists. The Glossary defines many of the terms.

Engineering soil classification systems

The two systems most commonly used in classifying soils for engineering are the Unified system (*2*), used by SCS engineers, the Department of Defense, and others, and the system adopted by the American Association of State Highway and Transportation Officials AASHTO (*1*).

In the Unified system, soils are classified according to particle-size distribution, plasticity, liquid limit, and organic matter. Soils are grouped in 15 classes. Soil materials are identified as coarse grained (eight classes), fine grained (six classes), or highly organic (one class). The coarse grained soils are identified as GC, GW, GP, GM, SW, SP, SM, and SC. The fine-grained soils are identified as ML, CL, OL, MH, CH, and OH. The highly organic soils are identified as Pt. Soils on the borderline between two classes are designated by symbols for both classes, for example, CL–ML.

The AASHTO system is used to classify soils according to properties that affect their use in highway construction and maintenance. In this system, a soil is placed in one of seven basic groups ranging from A–1 through A–7 on the basis of grain-size distribution, liquid limit, and plasticity index. In group A–1 are gravelly soils of high bearing strength, or the best soils for subgrade (foundation). At the other extreme,

[5] R. R. BOONE, area engineer, Soil Conservation Service, helped prepare this section.

TABLE 6.—*Estimated soil properties*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. The
in the first column of this table. The symbol >

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	USDA texture	Classification		Coarse fraction larger than 3 inches
				Unified	AASHTO	
	Feet	*Inches*				*Percent*
Arveson: Ar, As	1–3	0–10	Fine sandy loam or loam	SM or ML	A–4	0
		10–32	Fine sandy loam	SM	A–4	0
		32–60	Loamy fine sand or fine sand.	SM	A–4 or A–2	0
Arvilla: AvB	>5	0–17	Sandy loam	SM	A–4 or A–2	0
		17–60	Sand and gravel	SP or SM	A–1	<2
*Bearden:						
Bd	3–5	0–14	Silt loam	CL	A–6	0
		14–60	Silt loam	CL	A–6	0
Be, Bn, Bo, Bp, Bs	3–5	0–14	Silt loam and silty clay loam.	CL	A–7 or A–6	0
For Lindaas part of Bn, see Lindaas series; for Overly part of Bo, see Overly series; for Perella part of Bp, see Perella series; for Glyndon part of Bs, see Glyndon series.		14–60	Silt loam and silty clay loam.	CL	A–7 or A–6	0
Bg	3–5	0–14	Silty clay loam	CL	A–6 or A–7	0
		14–40	Silty clay loam	CL	A–6 or A–7	0
		40–60	Clay	CH		0
Beotia: Bt	>5	0–12	Silt loam	CL	A–6	0
		12–60	Silt loam	CL	A–6	0
*Bohnsack: Bu, Bv	3–5	0–8	Loam	ML or ML–CL	A–4	<4
For Tiffany part of Bv, see Tiffany series.		8–24	Loam	ML or ML–CL	A–4	<4
		24–60	Silt loam	ML	A–4	0
Borup:						
Bw	1–3	0–10	Silt loam	ML	A–4	0
		10–28	Silt loam	ML	A–4	0
		28–60	Very fine sandy loam	ML	A–4	0
Bx	1–3	0–10	Silt loam	ML	A–4	0
		10–28	Silt loam	ML	A–4	0
		28–60	Very fine sandy loam	ML	A–4	0
Cashel: CaA, CaC	[2]>5	0–60	Silty clay	CH	A–7	0
Colvin:						
Co	1–3	0–8	Silt loam	CL	A–6	0
		8–60	Silt loam	CL	A–6	0
Cs	1–3	0–8	Silt loam	CL	A–6	0
		8–60	Silt loam	CL	A–6	0
Cut and fill land: Cu. Properties too variable to be estimated.						
Divide: Dd	3–5	0–25	Loam	ML or CL, ML–CL	A–4 or A–6	0
		25–60	Coarse sand and gravel	GM or SM	A–1	<3

significant in engineering

soils in such mapping units may have different properties, and for this reason it is necessary to refer to other series as indicated means more than; the symbol < means less than]

Percentage smaller than 3 inches passing sieve—				Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Salinity	Shrink-swell potential	Corrosivity to—	
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)								Uncoated steel	Concrete
				Percent		*Inches per hour*	*Inches per inch of soil*	*pH*	*Millimhos per centimeter at 25° C*			
100	95–100	75–90	45–65	20–40	1–10	2.0–6.0	0.16–0.22	7.4–7.8	<2.0	Low	High	Low.
100	95–100	70–85	40–50	15–20	1–5	2.0–6.0	0.15–0.17	7.4–8.4	<2.0–4.0	Low	High	Low.
100	95–100	65–80	20–40	10–15	1–5	2.0–6.0	0.05–0.10	7.4–8.4	<2.0–4.0	Low	High	Low.
100	100	60–70	30–40	15–20	1–5	2.0–6.0	0.13–0.15	6.6–7.3	<2.0	Low	Moderate	Low.
85–95	60–80	20–50	0–15	[1] NP	[1] NP	>20	0.02–0.05	7.4–7.8	<2.0	Low	Moderate	Low.
100	100	90–100	80–90	20–40	10–25	0.2–0.6	0.10–0.15	7.4–7.8	4.0–8.0	Moderate	High	Moderate.
100	100	90–100	80–90	20–40	10–25	0.2–0.6	0.10–0.15	7.4–8.4	4.0–8.0	Moderate	High	Moderate.
100	100	95–100	85–95	30–50	10–30	0.2–0.6	0.18–0.20	7.4–7.8	<2.0	Moderate	High	Low.
100	100	95–100	85–95	30–50	10–30	0.2–0.6	0.17–0.19	7.4–8.4	<2.0–4.0	Moderate	High	Low.
100	100	95–100	85–95	30–50	10–30	0.2–0.6	0.17–0.24	7.4–7.8	<2.0	Moderate	High	Low.
100	100	95–100	85–95	30–50	10–30	0.2–0.6	0.17–0.24	7.4–8.4	<2.0	Moderate	High	Low.
100	100	95–100	85–95	50–70	35–50	0.06–0.2	0.13–0.15	7.4–8.4	<2.0–4.0	High	High	Low.
100	100	95–100	80–90	20–40	10–25	0.6–2.0	0.20–0.22	6.6–7.3	<2.0	Moderate	High	Low.
100	100	95–100	80–90	20–40	10–25	0.6–2.0	0.17–0.19	7.4–7.8	<2.0	Moderate	High	Low.
95–100	92–98	85–95	60–75	20–35	2–10	0.6–2.0	0.18–0.21	7.4–7.8	<2.0	Low	High	Low.
95–100	92–98	85–95	60–75	20–35	2–10	0.6–2.0	0.17–0.20	7.4–8.4	<2.0–4.0	Low	High	Low.
100	100	85–100	65–100	20–30	2–10	0.6–2.0	0.17–0.19	7.4–8.4	<2.0–4.0	Low	High	Low.
100	100	90–100	70–90	20–35	0–10	0.6–2.0	0.20–0.22	7.4–7.8	<2.0	Low	High	Low.
100	100	90–100	70–90	15–35	0–10	0.6–2.0	0.16–0.19	7.4–8.4	<2.0–4.0	Low	High	Low.
100	100	85–95	50–65	NP	NP	2.0–6.0	0.16–0.19	7.4–8.4	<2.0–4.0	Low	High	Low.
100	100	90–100	70–90	15–35	0–10	0.6–2.0	0.10–0.15	7.4–7.8	4.0–8.0	Low	High	Moderate.
100	100	90–100	70–90	15–35	0–10	0.6–2.0	0.10–0.15	7.4–8.4	4.0–8.0	Low	High	Moderate.
100	100	85–95	50–65	NP	NP	2.0–6.0	0.10–0.15	7.4–8.4	4.0–8.0	Low	High	Moderate.
100	100	95–100	90–95	50–70	25–45	0.2–0.6	0.18–0.20	7.4–7.8	<2.0	High	High	Low.
100	100	90–100	70–90	20–50	10–30	0.2–2.0	0.18–0.20	7.4–8.4	<2.0	Moderate	High	Low.
100	100	90–100	70–90	20–50	10–30	0.2–2.0	0.16–0.18	7.4–8.4	<2.0–4.0	Moderate	High	Low.
100	100	90–100	70–90	20–40	10–30	0.2–2.0	0.10–0.15	7.4–9.0	4.0–8.0	Moderate	High	Moderate.
100	100	90–100	70–90	20–40	10–30	0.2–2.0	0.10–0.15	7.4–9.0	4.0–8.0	Moderate	High	Moderate.
95–100	95–100	80–90	60–75	15–40	4–25	0.6–2.0	0.15–0.17	7.4–8.4	<2.0	Low	High	Low.
40–75	15–65	15–40	12–25	NP	NP	>20	0.3–0.5	7.4–8.4	<2.0	Low	High	Low.

TABLE 6.—*Estimated soil properties*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	USDA texture	Classification		Coarse fraction larger than 3 inches
				Unified	AASHTO	
	Feet	*Inches*				*Percent*
Doran: Do	3–5	0–8	Clay loam	CL	A–6	<2
		8–21	Clay and clay loam	CH or CL	A–7 or A–6	<2
		21–44	Clay loam	CL	A–6	<3
		44–60	Loam	CL	A–6	<3
Dovray: Dv	0–3	0–20	Silty clay	CH	A–7	0
		20–48	Clay	CH	A–7	0
		48–60	Clay	CH	A–7	0
Eckman Mapped only in complex with Gardena soils.	>5	0–15	Silt loam	ML	A–4	0
		15–21	Silt loam	ML	A–4	0
		21–60	Silt loam	ML	A–4	0
*Egeland: EdA, EgA, EgB For Embden parts of EgA and EgB, see Embden series.	>5	0–8	Loam and fine sandy loam	ML or SM	A–4	0
		8–37	Fine sandy loam	SM or ML	A–4	0
		37–60	Loamy fine sand	SM	A–2	0
Embden: Em, En	>5	0–19	Very fine sandy loam and fine sandy loam.	ML or SM	A–4	0
		19–27	Fine sandy loam	SM	A–4	0
		27–60	Fine sandy loam	SM	A–4	0
*Emrick:						
Eo	>5	0–9	Loam	ML	A–4	<2
		9–32	Loam	ML	A–4	<4
		32–60	Loam	ML	A–4	0
EpA For Heimdal part, see Heimdal series.	>5	0–9	Loam	ML	A–4	<2
		9–32	Loam	ML	A–4	<2
		32–60	Loam	ML	A–4	<2
Enloe Mapped only in complexes with Fargo and Hegne soils.	1–3	0–14	Silty clay loam and silty clay.	CL or CH	A–6 or A–7	0
		14–38	Clay	CH	A–7	0
		38–60	Silty clay	CH	A–7	0
Esmond Mapped only in complex with Heimdal soils.	>5	0–7	Loam	ML	A–4	<1
		7–46	Loam	ML	A–4	<1
		46–60	Loamy sand or loam	ML or SM	A–4 or A–4–2	0
Fairdale: FsA	[3]>5	0–60	Silt loam	ML or CL	A–4 or A–6	0
*Fargo: Fb, Fc, Fd, Fe, Fg, Fh, Fn For Dovray part of Fd, see Dovray series; for Enloe parts of Fe and Fg see Enloe series; for Hegne part of Fh, see Hegne series; for Ryan part of Fn, see Ryan series.	3–5	0–8	Silty clay or silty clay loam.	CL–CH	A–7	0
		8–21	Silty clay	CH	A–7	0
		21–60	Silty clay	CH	A–7	0
*Galchutt: Ga For Fargo part, see Fargo series.	1–3	0–16	Silty clay loam and silt loam.	CL	A–6	0
		16–24	Silt loam	CL or ML	A–6 or A–4	0
		24–60	Clay	CH	A–7	0
*Gardena: Gd, GeB, GfC For Eckman part of GeB, see Eckman series; for Zell part of GfC see Zell series.	>5	0–32	Silt loam	ML	A–4	0
		32–60	Silt loam	ML	A–4	0

significant in engineering—Continued

Percentage smaller than 3 inches passing sieve—				Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Salinity	Shrink-swell potential	Corrosivity to—	
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)								Uncoated steel	Concrete
				Percent		*Inches per hour*	*Inches per inch of soil*	*pH*	*Millimhos per centimeter at 25° C*			
95–100	90–100	90–100	70–80	25–40	15–25	0.2–0.6	0.17–0.20	6.6–7.3	<2.0	Moderate	High	Low.
95–100	90–100	90–100	70–95	25–75	15–45	0.2–0.6	0.15–0.19	6.6–7.8	<2.0	High	High	Low.
95–100	90–100	90–100	70–80	25–40	10–20	0.06–0.2	0.14–0.16	7.4–7.8	<2.0–4.0	High	High	Low.
95–100	90–100	85–95	60–75	20–40	10–20	0.06–0.2	0.16–0.18	7.4–7.8	<2.0–4.0	Moderate	High	Low.
100	100	100	90–95	50–75	25–50	0.06–0.2	0.17–0.20	6.6–7.3	<2.0	High	High	Low.
100	100	100	90–95	50–80	35–50	<0.06	0.15–0.17	6.6–7.8	<2.0	High	High	Low.
100	100	100	90–95	50–75	30–50	<0.06	0.14–0.16	7.4–7.8	<2.0	High	High	Low.
100	100	95–100	70–95	20–35	2–10	0.6–2.0	0.20–0.22	6.6–7.3	<2.0	Low	High	Low.
100	100	95–100	70–95	20–35	2–10	0.6–2.0	0.18–0.20	7.4–7.8	<2.0	Low	High	Low.
100	100	95–100	70–95	25–35	2–10	0.6–2.0	0.17–0.19	7.4–7.8	<2.0	Low	High	Low.
100	95–100	70–90	40–70	20–35	0–10	2.0–6.0	0.16–0.22	6.6–7.3	<2.0	Low	High	Low.
100	95–100	70–85	40–55	20–35	0–10	2.0–6.0	0.15–0.17	6.6–7.3	<2.0	Low	High	Low.
100	95–100	50–75	15–30	10–20	0–5	2.0–6.0	0.08–0.10	7.4–7.8	<2.0	Low	High	Low.
100	95–100	70–90	40–65	20–35	0–10	2.0–6.0	0.15–0.18	6.1–7.3	<2.0	Low	High	Low.
100	95–100	70–85	40–50	20–35	0–10	2.0–6.0	0.14–0.16	6.6–7.3	<2.0	Low	High	Low.
100	95–100	70–85	40–50	20–35	0–10	2.0–6.0	0.12–0.14	7.4–8.4	<2.0	Low	High	Low.
98–100	95–100	85–95	60–75	15–35	2–10	0.6–2.0	0.18–0.22	6.1–7.3	<2.0	Low	High	Low.
97–100	95–100	85–95	60–75	15–35	2–10	0.6–2.0	0.16–0.19	6.1–7.3	<2.0	Low	High	Low.
100	100	95–100	75–95	10–35	2–10	0.6–2.0	0.15–0.19	7.4–8.4	<2.0	Low	High	Low.
98–100	95–100	85–95	60–75	15–35	2–10	0.6–2.0	0.18–0.22	6.1–7.3	<2.0	Low	High	Low.
98–100	95–100	85–95	60–75	15–35	2–10	0.6–2.0	0.16–0.19	6.1–7.3	<2.0	Low	High	Low.
98–100	95–100	85–95	60–75	10–30	2–10	0.6–2.0	0.15–0.19	7.4–8.4	<2.0	Low	High	Low.
100	100	95–100	80–95	20–75	10–45	0.06–0.2	0.16–0.20	5.6–7.3	<2.0	High	High	Low.
100	100	95–100	80–95	50–75	30–45	0.06–0.2	0.15–0.18	6.1–7.8	<2.0	High	High	Low.
100	100	95–100	90–95	50–75	30–45	0.06–0.2	0.14–0.16	7.4–7.8	<2.0	High	High	Low.
98–100	95–100	85–95	60–75	20–35	2–10	0.6–2.0	0.20–0.22	6.6–7.8	<2.0	Low	High	Low.
98–100	95–100	85–95	60–75	20–35	2–10	0.6–2.0	0.16–0.18	7.4–7.8	<2.0	Low	High	Low.
98–100	95–100	50–90	20–70	0–35	0–10	0.6–2.0	0.08–0.18	7.4–7.8	<2.0	Low	High	Low.
100	100	90–100	65–85	25–40	4–20	0.6–2.0	0.18–0.20	7.4–7.8	<2.0	Low to moderate.	High	Low.
100	100	95–100	85–100	45–70	25–40	0.06–0.2	0.16–0.19	6.6–7.3	<2.0	High	High	Low.
100	100	95–100	90–100	50–75	30–45	0.06–0.2	0.16–0.19	6.6–7.8	<2.0	High	High	Low.
100	100	95–100	90–100	50–75	30–45	0.06–0.2	0.15–0.18	7.9–8.4	<2.0–4.0	High	High	Low.
100	100	95–100	85–95	25–40	15–25	0.6–2.0	0.18–0.21	6.1–6.5	<2.0	Moderate	High	Low.
100	100	95–100	70–95	25–40	7–20	0.6–2.0	0.16–0.20	6.6–7.3	<2.0	Moderate	High	Low.
100	100	95–100	90–100	55–70	35–50	0.06–0.2	0.13–0.16	6.6–7.8	<2.0	High	High	Low.
100	100	85–95	75–90	20–35	2–10	0.6–2.0	0.18–0.22	6.6–7.8	<2.0	Low	High	Low.
100	100	85–95	75–90	20–35	2–10	0.6–2.0	0.16–0.19	7.4–7.8	<2.0	Low	High	Low.

TABLE 6.—*Estimated soil properties*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	USDA texture	Classification		Coarse fraction larger than 3 inches
				Unified	AASHTO	
	Feet	*Inches*				*Percent*
*Gilby:						
Gg, Gh	1–3	0–8	Loam	ML or CL	A–4 or A–6	<2
For Tonka part of Gh, see Tonka series.		8–26	Loam	ML or CL	A–4 or A–6	<1
		26–60	Clay loam	CL	A–6	<3
Gk	1–3	0–26	Loam	ML or CL	A–4 or A–6	<2
For Tonka part, see Tonka series.		26–60	Clay loam	CL	A–6	<3
*Glyndon:						
Gm, Go	3–5	0–24	Silt loam	ML	A–4	0
For Perella part of Go, see Perella series.		24–60	Very fine sandy loam	ML	A–4	0
Gn	3–5	0–24	Silt loam	ML	A–4	0
		24–60	Very fine sandy loam	ML	A–4	0
Gr	3–5	0–24	Loam	ML	A–4	0
For Tiffany part, see Tiffany series.		24–60	Loam	ML	A–4	0
Grano: Gs	0–3	0–60	Silty clay	CH	A–7	0
Great Bend: GwA, GwC, GwD	>5	0–18	Silty clay loam	CL	A–6	0
		18–60	Silty clay loam	CL	A–6	0
Hamar: Ha	1–3	0–12	Loamy fine sand	SM	A–2	0
		12–44	Loamy fine sand	SM	A–2	0
		44–60	Fine sand	SM	A–2	0
*Hamerly:						
Hb	3–5	0–7	Clay loam	CL	A–6	<4
For Tonka part, see Tonka series.		7–15	Clay loam	CL	A–6	<4
		15–25	Clay loam	CL	A–6	<4
		25–60	Clay loam	CL	A–6	<3
Hc	3–5	0–7	Clay loam	CL	A–6	<4
For Tonka part, see Tonka series.		7–15	Clay loam	CL	A–6	<4
		15–25	Clay loam	CL	A–6	<4
		25–60	Clay loam	CL	A–6	<3
*Hecla: HeA, HfA, HmB	>5	0–14	Sandy loam, fine sandy loam, and loamy fine sand.	SM	A–2	0
For Maddock part of HmB, see Maddock series.		14–20	Loamy fine sand	SM	A–2	0
		20–60	Fine sand	SM	A–2	0
*Hegne: Hn, Ho	1–3	0–60	Silty clay	CH	A–7	0
For Enloe part of Hn, see Enloe series; for Fargo part of Ho, see Fargo series.						
*Heimdal: HrB, HsC	>5	0–21	Loam	ML	A–4	<1
For Emrick part of HrB, see Emrick series; for Esmond part of HsC, see Esmond series.		21–33	Loam	ML	A–4	<1
		33–60	Very fine sandy loam	ML	A–4	0
LaDelle: La	[2]>5	0–60	Silty clay loam	CL	A–6	0
Lamoure: Lm	[2]1–3	0–60	Silt loam and loam	ML or CL	A–6 or A–7	0

significant in engineering—Continued

Percentage smaller than 3 inches passing sieve—				Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Salinity	Shrink-swell potential	Corrosivity to—	
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)								Uncoated steel	Concrete
				Percent		*Inches per hour*	*Inches per inch of soil*	*pH*	*Millimhos per centimeter at 25° C*			
95–100	90–100	85–95	60–75	20–35	7–15	0.6–2.0	0.18–0.20	6.6–8.4	<2.0–4.0	Low	High	Low.
95–100	90–100	85–95	60–75	20–35	7–15	0.6–2.0	0.17–0.19	7.4–8.4	<2.0–4.0	Low	High	Low.
95–100	90–100	85–95	70–80	25–40	10–25	0.2–0.6	0.11–0.16	7.4–8.4	<2.0–8.0	Moderate	High	Low.
95–100	90–100	85–95	60–75	20–35	7–20	0.6–2.0	0.10–0.15	6.6–8.4	4.0–8.0	Low	High	Moderate.
95–100	90–100	85–95	70–80	25–40	10–25	0.2–0.6	0.10–0.15	7.4–8.4	4.0–8.0	Moderate	High	Moderate.
100	100	90–100	70–90	20–40	2–10	0.6–2.0	0.18–0.21	7.4–9.0	<2.0	Low	High	Low.
100	100	85–95	50–65	20–40	2–10	0.6–2.0	0.16–0.19	7.4–8.4	<2.0–4.0	Low	High	Low.
100	100	90–100	70–90	20–40	2–10	0.6–2.0	0.10–0.15	7.4–9.0	4.0–8.0	Low	High	Moderate.
100	100	85–95	50–65	20–40	2–10	0.6–2.0	0.10–0.15	7.4–8.4	4.0–8.0	Low	High	Moderate.
100	100	85–95	60–75	15–35	2–10	0.6–2.0	0.18–0.21	7.4–9.0	<2.0	Low	High	Low.
100	100	85–95	60–75	15–35	2–10	0.6–2.0	0.16–0.19	7.4–8.4	<2.0–4.0	Low	High	Low.
100	100	95–100	90–95	50–75	30–50	0.06–0.2	0.15–0.18	7.4–8.4	<2.0–4.0	High	High	Low.
100	100	95–100	85–95	25–40	10–30	0.6–2.0	0.17–0.20	6.6–7.3	<2.0	Moderate	High	Low.
100	100	95–100	85–95	25–40	10–30	0.6–2.0	0.16–0.19	7.4–7.8	<2.0	Moderate	High	Low.
100	100	90–100	12–25	0–20	0–10	6.0–20	0.12–0.14	6.1–7.3	<2.0	Low	High	Low.
100	100	90–100	15–30	NP	NP	6.0–20	0.08–0.10	6.6–7.8	<2.0	Low	High	Low.
100	100	85–100	20–35	NP	NP	6.0–20	0.05–0.07	6.6–7.8	<2.0	Low	High	Low.
94–100	90–98	85–95	60–80	25–40	15–25	0.6–2.0	0.17–0.20	7.4–7.8	<2.0–4.0	Moderate	High	Low.
94–100	90–98	85–95	60–80	25–40	15–25	0.6–2.0	0.15–0.19	7.4–8.4	<2.0–4.0	Moderate	High	Low.
94–100	90–98	85–95	60–80	25–40	15–25	0.2–0.6	0.15–0.19	7.4–8.4	<2.0–4.0	Moderate	High	Low.
95–100	90–98	85–95	60–80	25–40	10–25	0.2–0.6	0.14–0.18	7.4–8.4	4.0–16.0	Moderate	High	Moderate.
94–100	90–98	85–95	60–80	25–40	15–35	0.6–2.0	0.13–0.17	7.4–7.8	4.0–8.0	Moderate	High	Moderate.
94–100	90–98	85–95	60–80	25–40	15–35	0.6–2.0	0.11–0.16	7.4–8.4	4.0–8.0	Moderate	High	Moderate.
94–100	90–98	85–95	60–80	25–40	15–35	0.2–0.6	0.10–0.15	7.4–8.4	4.0–8.0	Moderate	High	Moderate.
95–100	90–98	85–95	60–80	25–40	10–35	0.2–0.6	0.09–0.14	7.4–8.4	4.0–16.0	Moderate	High	Moderate.
100	100	50–85	15–35	0–20	0–10	2.0–20	0.10–0.15	6.1–7.3	<2.0	Low	High	Low.
100	100	50–75	15–30	0–20	0–10	6.0–20	0.09–0.11	6.1–7.3	<2.0	Low	High	Low.
100	100	65–80	20–35	NP	NP	6.0–20	0.05–0.07	6.1–7.3	<2.0	Low	High	Low.
100	100	95–100	90–95	50–75	30–50	0.06–0.2	0.15–0.19	7.4–8.4	<2.0	High	High	Low.
98–100	95–100	85–95	60–75	15–35	4–10	0.6–2.0	0.18–0.22	6.6–7.3	<2.0	Low	High	Low.
98–100	95–100	85–95	60–75	15–35	4–10	0.6–2.0	0.17–0.19	7.4–8.4	<2.0	Low	High	Low.
98–100	95–100	85–95	50–65	20–40	0–10	0.6–2.0	0.16–0.18	7.4–8.4	<2.0	Low	High	Low.
100	100	95–100	80–90	20–45	10–25	0.6–2.0	0.17–0.20	6.6–8.4	<2.0	Moderate	High	Low.
100	100	90–100	70–90	25–45	10–30	0.6–2.0	0.16–0.19	7.4–8.4	<2.0–4.0	Moderate	High	Low.

TABLE 6.—*Estimated soil properties*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	USDA texture	Classification		Coarse fraction larger than 3 inches
				Unified	AASHTO	
	Feet	*Inches*				*Percent*
Lankin: Ln	3–5	0–21	Loam	ML or CL	A–4 or A–6	<1
		21–30	Clay loam	CL	A–6	<4
		30–60	Clay loam	CL	A–6	<3
La Prairie: Lp	[2] >5	0–60	Silt loam	ML or CL	A–6 or A–4	0
Lindaas	1–3	0–15	Silty clay loam and silt loam.	CL or ML	A–6 or A–7	0
		15–27	Silty clay	CH	A–7	0
Mapped only in complex with Bearden soils.		27–60	Silty clay loam and silt loam.	CL or ML	A–6 or A–7	0
Ludden: Lu	[2] 1–3	0–60	Silty clay	CH	A–7	0
Maddock	>5	0–11	Sandy loam and loamy sand	SM	A–2 or A–4	0
Mapped only in complexes with Hecla and Serden soils.		11–25	Loamy sand	SM	A–2 or A–4	0
		25–60	Fine sand	SM	A–2	0
Marsh: Ma. Properties too variable to be estimated.						
Nahon: Na	>5	0–12	Silt loam	ML	A–6	0
		12–21	Clay	CH	A–7	0
		21–60	Silty clay	CH	A–7	0
Nutley: NuA, NuB, NuC, NuD, NuE	>5	0–60	Silty clay	CH	A–7	0
Ojata: Oa	1–3	0–7	Silty clay loam	CL	A–6	0
		7–30	Silty clay loam	CL	A–6	0
		30–60	Silt loam	CL	A–6	0
*Overly: Or, OvB	>5	0–22	Silty clay loam	CL	A–6 or A–7	0
For Great Bend part of OvB, see Great Bend series.		22–60	Silty clay loam	CL	A–6 or A–7	0
Os	>5	0–22	Silty clay loam	CL	A–6 or A–7	0
For Fargo part, see Fargo series.		22–40	Silty clay loam	CL	A–6 or A–7	0
		40–60	Clay	CH	A–7	0
Perella: Pe	1–3	0–60	Silt loam and silty clay loam.	CL	A–6 or A–7	0
Playmoor: Pr	[2] 1–3	0–9	Silty clay loam	CL	A–6 or A–7	0
		9–60	Silty clay loam	CL	A–6 or A–7	0
Renshaw: ReA	>5	0–12	Loam	ML	A–4	0
		12–18	Loam	ML	A–4	0
		18–60	Coarse sand and gravel	GM or SM	A–1	<5
Rockwell: Ro	1–3	0–26	Fine sandy loam	SM	A–4	0
		26–60	Clay loam	CL	A–6	<2

significant in engineering—Continued

Percentage smaller than 3 inches passing sieve—				Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Salinity	Shrink-swell potential	Corrosivity to—	
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)								Uncoated steel	Concrete
				Percent		*Inches per hour*	*Inches per inch of soil*	*pH*	*Millimhos per centimeter at 25° C*			
98–100	95–100	85–95	60–75	20–35	4–20	0.6–2.0	0.18–0.22	6.6–7.3	<2.0	Low	High	Low.
95–100	85–95	70–90	65–80	25–50	10–30	0.6–2.0	0.15–0.19	6.6–7.8	<2.0	Moderate	High	Low.
95–100	85–95	70–90	65–80	25–50	10–30	0.2–0.6	0.14–0.16	7.4–8.4	<2.0–4.0	Moderate	High	Low.
100	100	90–100	70–90	17–40	4–20	0.6–2.0	0.17–0.20	6.6–7.8	<2.0	Low to moderate.	High	Low.
100	100	95–100	85–95	25–50	10–25	0.06–0.2	0.17–0.22	6.6–7.3	<2.0	Moderate	High	Low.
100	100	95–100	80–95	50–70	30–45	0.06–0.2	0.15–0.17	7.4–7.8	<2.0	High	High	Low.
100	100	95–100	75–95	25–50	10–25	0.06–0.2	0.16–0.18	7.4–8.4	<2.0	Moderate	High	Low.
100	100	95–100	90–95	50–75	30–50	0.06–0.2	0.15–0.18	7.4–8.4	<2.0–4.0	High	High	Moderate.
100	100	50–75	15–40	0–20	0–10	6.0–20	0.10–0.15	6.1–7.3	<2.0	Low	Moderate	Low.
100	100	50–75	20–40	NP	NP	6.0–20	0.09–0.12	6.6–7.3	<2.0	Low	Moderate	Low.
100	100	65–80	20–35	NP	NP	6.0–20	0.05–0.07	6.6–7.8	<2.0	Low	Moderate	Low.
100	100	90–100	80–90	20–35	4–10	0.6–2.0	0.18–0.20	6.6–7.3	<2.0	Low	High	Moderate.
100	100	95–100	90–95	50–75	35–50	<0.06	0.10–0.14	7.4–8.4	2.0–8.0	High	High	Moderate.
100	100	95–100	90–95	50–75	35–50	<0.06	0.09–0.13	7.9–9.0	4.0–8.0	High	High	High.
100	100	95–100	90–95	50–75	35–50	0.06–0.2	0.15–0.19	7.4–7.8	<2.0	High	High	Low.
100	100	95–100	85–95	25–40	10–25	0.06–0.2	0.11–0.16	7.9–8.4	8.0–16.0	Moderate	Very high	High.
100	100	95–100	85–95	25–40	10–25	0.06–0.2	0.10–0.15	7.9–8.4	8.0–16.0	Moderate	Very high	High.
100	100	90–100	70–90	20–40	10–25	0.06–0.2	0.09–0.14	7.9–8.4	8.0–16.0	Moderate	Very high	High.
100	100	95–100	85–95	25–45	10–30	0.2–0.6	0.17–0.20	6.1–7.3	<2.0	Moderate	High	Low.
100	100	95–100	85–95	25–45	10–30	0.2–0.6	0.16–0.19	7.4–8.4	<2.0	Moderate	High	Low.
100	100	95–100	85–95	25–45	10–30	0.2–0.6	0.17–0.20	6.1–7.3	<2.0	Moderate	High	Low.
100	100	95–100	85–95	25–45	10–30	0.2–0.6	0.16–0.19	7.4–7.8	<2.0	Moderate	High	Low.
100	100	95–100	90–95	50–75	35–45	0.06–0.2	0.13–0.15	7.4–8.4	<2.0	High	High	Low.
100	100	95–100	75–95	25–50	10–30	0.2–0.6	0.17–0.20	6.6–7.8	<2.0	Moderate	High	Low.
100	100	95–100	85–95	25–50	15–35	0.2–0.6	0.10–0.15	7.4–8.4	4.0–8.0	Moderate	High	High.
100	100	95–100	85–95	25–50	15–35	0.2–0.6	0.10–0.15	7.9–8.4	4.0–8.0	Moderate	High	High.
95–100	90–100	85–95	60–75	15–38	0–10	2.0–6.0	0.18–0.20	6.6–7.3	<2.0	Low	High	Low.
95–100	90–100	85–95	60–75	15–38	0–10	2.0–6.0	0.18–0.20	7.4–7.8	<2.0	Low	High	Low.
30–70	15–50	10–40	3–25	NP	NP	>20	0.02–0.05	7.4–8.4	<2.0	Low	High	Low.
100	95–100	70–85	36–50	15–35	3–10	0.6–2.0	0.16–0.20	7.4–7.8	<2.0	Low	High	Low.
97–100	95–100	90–100	70–80	25–40	11–30	0.2–0.6	0.14–0.18	7.4–8.4	<2.0–4.0	Moderate	High	Low.

TABLE 6.—*Estimated soil properties*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	USDA texture	Classification		Coarse fraction larger than 3 inches
				Unified	AASHTO	
	Feet	*Inches*				*Percent*
Ryan	1–3	0–8	Silty clay	CH	A–7	0
Mapped only in complex with Fargo soil.		8–15	Silty clay	CH	A–7	0
		15–60	Silty clay	CH	A–7	0
*Serden: SmB	>5	0–3	Loamy sand	SM	A–2	0
For Maddock part, see Maddock series.		3–15	Sand	SP	A–3	0
		15–60	Sand	SP	A–3	0
*Sioux: SrB	>5	0–6	Gravelly sandy loam	SM	A–2	<3
For Arvilla part, see Arvilla series.		6–60	Coarse sand and gravel	GM or SM	A–1	<5
Swenoda: Sv, Sw	>5	0–8	Loam and fine sandy loam	ML or SM	A–4	0
		8–22	Fine sandy loam	ML or SM	A–4	0
		22–60	Silt loam	CL	A–6	0
Tiffany: Tf	1–3	0–10	Loam and fine sandy loam	ML or SM	A–4	0
		10–24	Fine sandy loam	SM	A–4	0
		24–60	Fine sandy loam	SM	A–4	0
Tonka: To	0–3	0–8	Silt loam or clay loam	ML or CL	A–4 or A–6	0
		8–19	Loam	ML	A–4	0
		19–36	Clay	CH	A–7	0
		36–60	Clay loam	CL	A–6	0
Towner: TrA	3–5	0–8	Sandy loam	SM	A–4 or A–2	0
		8–17	Sandy loam	SM	A–4 or A–2	0
		17–31	Loamy sand	SM	A–2	0
		31–60	Loam	CL	A–6	<2
Ulen: Un	1–3	0–10	Fine sandy loam	SM	A–4	0
		10–42	Loamy fine sand	SM	A–2	0
		42–60	Fine sand	SM	A–2	0
*Vallers: Vd	1–3	0–10	Clay loam	CL	A–6	<4
For Doran part, see Doran series.		10–27	Clay loam	CL	A–6	<4
		27–60	Clay loam	CL	A–6	<3
Viking: Vk	1–3	0–18	Clay	CH	A–7	<2
		18–25	Clay	CH	A–7	<2
		25–60	Clay	CH	A–7	<2
Wahpeton: WaA	[2] >5	0–30	Silty clay	CH	A–7	0
		30–60	Silty clay	CH	A–7	0
Wheatville: Wh	1–3	0–29	Silt loam	ML	A–4	0
		29–60	Clay	CH	A–7	0
*Wyndmere:						
Wn, Wo, Wt	3–5	0–8	Fine sandy loam and loam	ML or SM	A–4	0
For Tiffany part of Wt, see Tiffany series.		8–14	Fine sandy loam and loam	ML or SM	A–4	0
		14–60	Fine sandy loam	SM	A–2	0
Ws	3–5	0–14	Loam	ML	A–4	0
		14–60	Fine sandy loam	SM	A–4	0
Zell: ZeE	>5	0–36	Silt loam	ML	A–4	0
		36–60	Silt loam	ML	A–4	0

[1] NP means nonplastic.

significant in engineering—Continued

Percentage smaller than 3 inches passing sieve—				Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Salinity	Shrink-swell potential	Corrosivity to—	
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)								Uncoated steel	Concrete
				Percent		*Inches per hour*	*Inches per inch of soil*	*pH*	*Millimhos per centimeter at 25° C*			
100	100	95–100	85–95	50–75	35–50	<0.06	0.10–0.15	7.4–8.4	<2.0	High	High	Moderate.
100	100	95–100	85–95	50–75	35–50	<0.06	0.10–0.15	7.9–9.0	<2.0–4.0	High	High	Moderate.
100	100	95–100	85–95	50–75	35–50	<0.06	0.10–0.15	7.9–9.0	4.0–16.0	High	High	Moderate.
100	100	50–75	15–30	NP	NP	6.0–20.0	0.10–0.12	6.1–7.3	<2.0	Low	Moderate	Low.
100	95–100	90–100	0–5	NP	NP	6.0–20.0	0.05–0.08	6.1–7.3	<2.0	Low	Moderate	Low.
100	95–100	90–100	0–5	NP	NP	6.0–20.0	0.04–0.06	6.6–7.3	<2.0	Low	Moderate	Low.
95–100	75–85	45–55	25–35	15–30	3–10	2.0–6.0	0.13–0.15	6.6–7.8	<2.0	Low	Moderate	Low.
30–70	20–50	10–35	3–25	NP	NP	>20	0.02–0.05	7.4–7.8	<2.0	Low	Moderate	Low.
100	90–100	75–90	45–70	25–40	2–10	2.0–6.0	0.12–0.18	6.6–7.3	<2.0	Low	High	Low.
100	90–100	70–85	40–55	25–40	2–10	2.0–6.0	0.11–0.15	6.6–7.3	<2.0	Low	High	Low.
100	95–100	80–95	70–90	25–35	11–25	0.6–2.0	0.11–0.14	7.4–8.4	<2.0–4.0	Moderate	High	Low.
100	100	70–90	40–70	20–35	2–10	0.6–6.0	0.12–0.17	6.1–7.3	<2.0	Low	High	Low.
100	100	70–85	40–50	20–35	0–10	0.6–6.0	0.11–0.15	6.6–7.3	<2.0	Low	High	Low.
100	100	70–85	40–50	20–35	0–10	0.6–6.0	0.10–0.13	6.1–7.8	<2.0	Low	High	Low.
100	95–100	90–100	70–90	20–40	7–25	0.06–0.2	0.17–0.20	5.6–6.5	<2.0	Low	High	Low.
100	95–100	85–95	60–75	20–35	2–10	0.06–0.2	0.17–0.19	5.6–7.3	<2.0	Low	High	Low.
100	95–100	90–100	75–95	50–65	25–40	0.06–0.2	0.14–0.17	5.6–7.3	<2.0	High	High	Low.
100	95–100	90–100	70–80	20–40	10–30	0.06–0.2	0.14–0.16	6.6–7.8	<2.0	Moderate	High	Low.
100	100	60–70	30–40	10–30	0–5	6.0–20.0	0.13–0.15	6.1–7.3	<2.0	Low	High	Low.
100	100	60–70	30–40	10–30	0–5	6.0–20.0	0.12–0.14	6.6–7.3	<2.0	Low	High	Low.
100	95–100	50–75	15–30	10–25	0–5	6.0–20.0	0.09–0.11	6.6–7.8	<2.0	Low	High	Low.
95–100	95–100	85–95	60–75	25–50	4–30	0.2–0.6	0.13–0.16	7.4–8.4	<2.0	Moderate	High	Low.
100	95–100	70–85	40–50	20–30	2–10	6.0–20.0	0.10–0.12	7.4–8.4	<2.0	Low	High	Low.
100	95–100	50–75	20–35	10–20	0–10	6.0–20.0	0.09–0.10	7.4–8.4	<2.0	Low	High	Low.
100	95–100	65–80	20–35	NP	NP	6.0–20.0	0.05–0.07	7.4–8.4	<2.0	Low	High	Low.
95–100	90–95	85–95	60–80	25–40	15–25	0.2–0.6	0.17–0.20	7.4–8.4	<2.0	Moderate	High	Low.
95–100	90–95	85–95	60–80	25–40	15–25	0.2–0.6	0.15–0.19	7.4–8.4	<2.0–4.0	Moderate	High	Low.
95–100	90–98	85–95	60–80	25–40	15–25	0.2–0.6	0.14–0.18	7.4–8.4	4.0–8.0	Moderate	High	Low.
98–100	95–100	95–100	85–95	50–75	35–50	<0.06	0.16–0.19	6.6–8.4	<2.0	High	High	Low.
98–100	95–100	95–100	85–95	50–75	35–50	<0.06	0.15–0.18	7.4–8.4	<2.0	High	High	Low.
98–100		95–100	85–95	50–75	35–50	<0.06	0.14–0.16	7.4–8.4	<2.0–4.0	High	High	Low.
100	100	95–100	90–95	50–75	30–50	0.6–2.0	0.16–0.19	6.6–7.3	<2.0	High	High	Low.
100	100	95–100	90–95	50–75	30–50	0.6–2.0	0.15–0.18	6.6–7.8	<2.0	High	High	Low.
100	100	90–100	70–90	20–40	2–10	2.0–6.0	0.19–0.21	7.4–7.8	<2.0	Low	High	Low.
100	100	95–100	90–95	50–75	35–45	0.06–0.2	0.13–0.15	7.4–7.8	<2.0–4.0	High	High	Low.
100	100	70–90	40–70	15–35	2–10	2.0–6.0	0.14–0.18	7.4–8.4	<2.0	Low	High	Low.
100	100	70–90	40–70	15–35	2–10	2.0–6.0	0.10–0.15	7.4–8.4	<2.0	Low	High	Low.
100	100	70–85	15–30	NP	0–10	2.0–6.0	0.10–0.14	7.4–8.4	<2.0–4.0	Low	High	Low.
100	100	85–95	60–75	20–40	2–10	2.0–6.0	0.10–0.15	6.6–7.8	4.0–8.0	Low	High	Moderate.
100	100	70–85	15–30	NP	0–10	2.0–6.0	0.05–0.10	7.9–8.4	4.0–8.0	Low	High	Moderate.
100	100	90–100	70–90	20–40	2–10	0.6–2.0	0.17–0.19	6.6–8.4	<2.0	Low	High	Low.
100	100	90–100	70–90	20–40	2–10	0.6–2.0	0.15–0.17	7.4–8.4	<2.0	Low	High	Low.

[2] Subject to flooding.

in group A–7, are clay soils that have low strength when wet and that are the poorest soils for subgrade. Where laboratory data are available to justify a further breakdown, the A–1, A–2, and A–7 groups are divided as follows: A–1–a, A–1–b, A–2–4, A–2–5, A–2–6, A–2–7, A–7–5, and A–7–6. The estimated AASHTO classification is given in table 6 for all soils mapped in the survey area.

Soil properties significant in engineering

Several estimated soil properties significant in engineering are given in table 6. These estimates are made for typical soil profiles, by layers sufficiently different to have different significance for soil engineering. The estimates are based on field observations made in the course of mapping, on test data for these and similar soils, and on experience with the same kinds of soil in other counties. All of the soils in Traill County are 10 feet or more deep to bedrock, and, consequently, a column headed "Depth to bedrock" is not given in table 6. Following are explanations of some of the columns in table 6.

Depth to seasonal high water table is the distance from the surface of the soil to the highest level that ground water reaches in the soil in most years.

Soil texture is described in table 6 in the standard terms used by the U.S. Department of Agriculture. These terms take into account relative percentages of sand, silt, and clay in soil material that is less than 2 millimeters in diameter. "Loam," for example, is soil material that contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the soil contains gravel or other particles coarser than sand, an appropriate modifier is added, for example, "gravelly sandy loam." "Sand," "silt," "clay," and some of the other terms used are defined in the Glossary of this soil survey.

Liquid limit and plasticity index indicate the effect of water on the strength and consistence of soil material. As the moisture content of a clayey soil is increased from a dry state, the material changes from semisolid to plastic. If the moisture content is further increased, the material changes from plastic to liquid. The plastic limit is the moisture content at which the soil material changes from semisolid to plastic; and the liquid limit, from plastic to liquid. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is plastic.

Permeability is that quality of a soil that enables it to transmit water or air. It is estimated on the basis of those soil characteristics observed in the field, particularly structure, porosity, and texture. The estimates do not take into account lateral seepage or such transient soil features as plowpans and surface crusts.

Available water capacity is the ability of soils to hold water for use by most plants. It is commonly defined as the difference between the amount of water in the soil at field capacity and the amount at the wilting point of most crop plants.

Reaction is the degree of acidity or alkalinity of a soil, expressed in pH values. The pH value and terms used to describe soil reaction are explained in the Glossary.

Salinity refers to the amount of soluble salts in the soil. It is expressed as the electrical conductivity of a saturation extract, in millimhos per centimeter at 25° C (*6*). Salinity affects the suitability of a soil for crops, its stability when used as construction material, and its corrosiveness to metals and concrete.

Shrink-swell potential is the relative change in volume of soil material to be expected with changes in moisture content, that is, the extent to which the soil shrinks as it dries out or swells when it gets wet. Extent of shrinking and swelling is influenced by the amount and kind of clay in the soil. Shrinking and swelling of soils cause much damage to building foundations, roads, and other structures. A *high* shrink-swell potential indicates a hazard to the maintenance of structures built in, on, or with material having this rating.

Corrosivity, as used in table 6, pertains to potential soil-induced chemical action that dissolves or weakens uncoated steel or concrete. Rate of corrosion of uncoated steel is related to soil properties such as drainage, texture, total acidity, and electrical conductivity of the soil material. Installations of steel that intersect soil boundaries or soil horizons are more susceptible to corrosion than installations entirely in one kind of soil or in one soil horizon. Corrosivity to concrete is influenced not only by the content of sodium or magnesium sulfate but also by soil texture and acidity. A corrosivity rating of *low* means that there is a low risk of corrosion damage. A rating of *high* means that there is a high risk of damage, so that protective measures for steel and more resistant concrete should be used to avoid or minimize damage.

Engineering interpretations

The estimated interpretations in tables 7 and 8 are based on the engineering properties of soils shown in table 6, on test data for soils in this survey area and others nearby or adjoining, and on the experience of engineers and soil scientists with the soils of Traill County. In tables 7 and 8, summarized limitations or ratings of suitability of the soils are given for all purposes other than for ponds and reservoirs, embankments, dikes and levees, drainage of cropland and pasture, irrigation, terraces and diversions, and grassed waterways. For these particular uses, table 8 lists those soil features not to be overlooked in planning, installation, and maintenance.

In table 7, soil limitations are expressed as *slight*, *moderate*, and *severe*. *Slight* means soil properties generally are favorable for the given use, or, in other words, limitations are minor and easily overcome. *Moderate* means that some soil properties are unfavorable but can be overcome or modified by special planning and design. *Severe* means soil properties are so unfavorable and so difficult to correct or overcome that major soil reclamation, special designs, or intensive maintenance are required.

In table 8, soil suitability is rated by the terms *good*, *fair*, and *poor*, which have meanings approximately parallel to the terms slight, moderate, and severe.

Following are explanations of some of the column headings in table 7.

Septic tank absorption fields are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into natural soil. The soil material from

a depth of 18 inches to 6 feet is evaluated. The soil properties considered are those that affect both absorption of effluent and construction and operation of the system. Properties that affect absorption are permeability, depth to water table or rock, and susceptibility to flooding. Slope affects difficulty of layout and construction and also the risk of soil erosion, lateral seepage, and downslope flow of effluent. Large rocks or boulders increase construction costs.

Sewage lagoons are shallow ponds constructed to hold sewage within a depth of 2 to 5 feet long enough for bacteria to decompose the solids. A lagoon has a nearly level floor; its sides, or embankments, are of soil material compacted to medium density, and the pond is protected from flooding. Properties that affect the pond floor are permeability, organic matter, and slope, and if the floor requires leveling, depth to bedrock becomes important. The soil properties that affect the embankment are the engineering properties of the embankment material as interpreted from the Unified Soil Classification and the amount of stones, if any, that influence the ease of excavation and compaction of the embankment material.

Shallow excavations are those that require digging or trenching to a depth of less than 6 feet, for example, excavations for pipelines, sewer lines, phone and power transmission lines, basements, open ditches, and cemeteries. Desirable soil properties are good workability, moderate resistance to sloughing, gentle slopes, absence of rock outcrops or large stones, and freedom from flooding or absence of a high water table.

Dwellings with basements are not more than three stories high and are supported by foundation footings placed in undisturbed soil. The features that affect the rating of a soil for dwellings are those that relate to capacity to support load and resist settlement under load, and those that relate to ease of excavation. Soil properties that affect capacity to support load are wetness, susceptibility to flooding, density, plasticity, texture, and shrink-swell potential. Those that affect excavation are wetness, slope, depth to bedrock, and content of stones and rocks.

Roads and streets have an all-weather surface expected to carry automobile traffic all year. They have a subgrade of underlying soil material; a base consisting of gravel, crushed rock, or soil material stabilized with lime or cement; and a flexible or rigid surface, commonly asphalt or concrete. These roads are graded to shed water and have ordinary provisions for drainage. They are built mainly from soil at hand, and most cuts and fills are less than 6 feet deep.

Soil properties that most affect design and construction of roads and streets are load-supporting capacity, stability of the subgrade, and the workability and quantity of cut and fill material available. The AASHTO and Unified classifications of the soil material and the shrink-swell potential indicate traffic-supporting capacity. Wetness and flooding affect stability of the material. Slope, depth to hard rock, content of stones and rocks, and wetness affect ease of excavation and the amount of cut and fill material needed to reach an even grade.

Sanitary landfill is a method of disposing of refuse in dug trenches. The waste is spread in thin layers, compacted, and covered with soil throughout the disposal period. Landfill areas are subject to heavy vehicular traffic. Among the soil properties that affect suitability for landfill are ease of excavation, hazard of polluting ground water, and trafficability. The best soils have moderately slow permeability, withstand heavy traffic, and are friable and easy to excavate. Unless otherwise stated the limitations apply only to the soil material to a depth of about 6 feet, and therefore, a limitation of *slight* or *moderate* may not be valid if trenches are to be much deeper than that. Each site should be investigated before one is selected.

The area-type sanitary landfill is a method of disposing of refuse by placing it on the surface of the soil in successive layers. Generally the daily and final cover material must be imported. A final cover of soil material, at least 2 feet thick, is placed over the fill when it is completed. Among the soil properties that affect suitability are the hazard of ground water pollution, soil drainage, and trafficability. Unless otherwise stated, the ratings in table 7 apply only to a depth of about 6 feet. Each site should be investigated before one is selected.

Following are explanations of the columns in table 8.

Cover material is the soil material used as a cover for the area-type sanitary landfill and the final cover for both area and trench-type sanitary landfills. Properties that affect the suitability of a soil for cover are workability; ease of excavating, moving, and spreading over the refuse daily during both wet and dry periods; and slope, permeability, and thickness of the soil material.

Roadfill is soil material used in making embankments for roads. The suitability ratings reflect the predicted performance of a soil after it has been placed in an embankment that has been properly compacted and provided with adequate drainage and the relative ease of excavating the material at borrow areas.

Sand and gravel are used in great quantities in many kinds of construction. The ratings in table 8 provide guidance about where to look for probable sources. A soil rated as a *good* or *fair* source of sand or gravel generally has a layer at least 3 feet thick, the top of which is within a depth of 6 feet. The ratings do not take into account thickness of overburden, depth to the water table, or other factors that affect mining of the materials. They also do not indicate the quality of the deposit.

Topsoil is used for topdressing an area where vegetation is to be established and maintained. Properties that affect suitability are mainly the ease of working and spreading the soil material, such as preparing a seedbed; the natural fertility of the material, or the response of plants to fertilizer; and the absence of substances toxic to plants. Other properties that affect suitability are the texture of the soil material and the content of stone fragments. Damage that results in areas where topsoil is removed is also considered.

Pond reservoir areas hold water behind a dam or embankment. Soils suitable for pond reservoir areas have low seepage, which is related to their permeability and depth to fractured or permeable bedrock or other permeable material.

Embankments, dikes, and levees require soil material that is resistant to seepage and piping and has strength, and compactibility. The presence of stones

TABLE 7.—*Interpretations*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. The
as indicated in the first

Soil series and map symbols	Degree and kind of limitations for—	
	Septic tank absorption fields	Sewage lagoons
Arveson: Ar, As	Severe: seasonal water table.	Severe: seasonal water table; moderately rapid permeability.
Arvilla: AvB	Slight [1]	Severe: very rapid permeability in substratum.[1]
*Bearden: Bd, Be, Bn, Bo, Bp, Bs For Lindaas part of Bn, see Lindaas series; for Overly part of Bo, see Overly series; for Perella part of Bp, see Perella series; for Glyndon part of Bs, see Glyndon series.	Severe: moderately slow permeability; seasonal water table.	Moderate: seasonal water table.
Bg	Severe: slow permeability in substratum; seasonal water table.	Moderate: seasonal water table.
Beotia: Bt	Moderate: moderate permeability.	Moderate: moderate permeability.
*Bohnsack: Bu, Bv For Tiffany part of Bv, see Tiffany series.	Severe: seasonal water table.	Severe: seasonal water table
Borup: Bw, Bx	Severe: seasonal water table.	Severe: seasonal water table; moderately rapid permeability in substratum.
Cashel: CaA, CaC	Severe: moderately slow permeability; subject to flooding.	Severe: subject to flooding
Colvin: Co, Cs	Severe: seasonal water table; moderately slow permeability.	Severe: seasonal water table
Cut and fill land: Cu. Properties too variable for reliable interpretations.		
Divide: Dd	Severe: seasonal water table.[1]	Severe: very rapid permeability in substratum; seasonal water table.[1]
Doran: Do	Severe: slow permeability in substratum; seasonal water table.	Slight
Dovray: Dv	Severe: very slow permeability; seasonal water table.	Slight

for land use planning

soils in such mapping units may have different properties and limitations, and for this reason it is necessary to refer to other series column of this table]

Degree and kind of limitations for—Continued				
Shallow excavations	Dwellings with basements	Roads and streets	Sanitary landfill	
			Trench	Area
Severe: poorly drained; seasonal water table.	Severe: poorly drained; seasonal water table.	Severe: poorly drained.	Severe: seasonal water table; poorly drained; moderately rapid permeability.	Severe: seasonal water table; poorly drained; moderately rapid permeability.
Severe: sand and gravel substratum.	Slight	Slight	Severe: very rapid permeability in substratum; texture of substratum.[1]	Severe: very rapid permeability in substratum.[1]
Severe: somewhat poorly drained.	Severe: somewhat poorly drained.	Severe: high frost action potential.	Severe: seasonal water table.	Moderate: somewhat poorly drained; seasonal water table.
Severe: somewhat poorly drained; clay substratum.	Severe: somewhat poorly drained; high shrink-swell potential in substratum.	Severe: high frost action potential; high shrink-swell potential in substratum.	Severe: seasonal water table; poor workability in substratum.	Moderate: somewhat poorly drained; seasonal water table.
Slight	Moderate: moderate shrink-swell potential.	Moderate: moderate shrink-swell potential.	Slight	Slight.
Severe: somewhat poorly drained.	Severe: somewhat poorly drained.	Severe: high frost action potential.	Severe: seasonal water table.	Moderate: seasonal water table; somewhat poorly drained.
Severe: poorly drained; seasonal water table.	Severe: poorly drained; seasonal water table.	Severe: poorly drained.	Severe: seasonal water table; poorly drained.	Severe: seasonal water table; poorly drained; moderately rapid permeability in substratum.
Severe: somewhat poorly drained; subject to flooding.	Severe: somewhat poorly drained; subject to flooding.	Severe: subject to flooding, high shrink-swell potential.	Severe: subject to flooding; silty clay.	Severe: subject to flooding.
Severe: poorly drained; seasonal water table.	Severe: poorly drained; seasonal water table.	Moderate: somewhat poorly drained.	Severe: seasonal water table; poorly drained.	Severe: seasonal water table; poorly drained.
Severe: somewhat poorly drained.	Severe: somewhat poorly drained.	Severe: poorly drained.	Severe: seasonal water table; very rapid permeability in substratum; coarse sand and gravel substratum.[1]	Severe: very rapid permeability in substratum.[1]
Severe: somewhat poorly drained; poor workability.	Severe: somewhat poorly drained; high shrink-swell potential.	Severe: high frost action potential; high shrink-swell potential.	Severe: seasonal water table.	Moderate: somewhat poorly drained; seasonal water table.
Severe: poorly drained and very poorly drained; poor workability.	Severe: poorly drained and very poorly drained; seasonal water table; high shrink-swell potential.	Severe: poorly drained and very poorly drained; high shrink-swell potential.	Severe: poorly drained and very poorly drained; seasonal water table; poor workability.	Severe: poorly drained and very poorly drained; seasonal water table; subject to ponding.

TABLE 7.—*Interpretations for*

Soil series and map symbols	Degree and kind of limitations for—	
	Septic tank absorption fields	Sewage lagoons
Eckman Mapped only in complex with Gardena soils.	Slight	Moderate: moderate permeability; slope.
*Egeland: EdA, EgA, EgB For Embden parts of EqA and EqB, see Embden series.	Slight [1]	Severe: moderately rapid permeability.[1]
Embden: Em, En	Slight [1]	Severe: moderately rapid permeability.[1]
*Emrick: Eo EpA For Heimdal part of EpA, see Heimdal series.	Slight	Moderate: moderate permeability.
Enloe Mapped only in complexes with Fargo and Hegne soils.	Severe: slow permeability; seasonal water table.	Slight
Esmond Mapped only in complex with Heimdal soils.	Slight	Severe: slope
Fairdale: FaA	Severe: subject to flooding	Severe: subject to flooding
*Fargo: Fb, Fc, Fd, Fe, Fg, Fh, Fn For Dovray part of Fd, see Dovray series; for Enloe part of Fe and Fg see Enloe series; for Hegne part of Fn, see Hegne series; for Ryan part of Fn, see Ryan series.	Severe: slow permeability; seasonal water table.	Slight
*Galchutt: Ga For Fargo part, see Fargo series.	Severe: slow permeability in substratum; seasonal water table.	Slight
*Gardena: Gd, GeB, GfC For Eckman part of GeB, see Eckman series; for Zell part of GfC see Zell series.	Slight	Moderate: moderate permeability.
*Gilby: Gg Gh, Gk For Tonka parts of Gh and Gk, see Tonka series.	Severe: moderately slow permeability in substratum; seasonal water table.	Severe: seasonal water table
*Glyndon: Gm Gn, Go, Gr For Perella part of Go, see Perella series; for Tiffany part of Gr, see Tiffany series.	Severe: seasonal water table	Severe: seasonal water table
Grano: Gs	Severe: slow permeability; seasonal water table.	Slight
Great Bend: GwA, GwC, GwD	Slight: 0 to 9 percent slopes Moderate: 9 to 15 percent slopes.	Moderate: moderate permeability; 3 to 6 percent slopes. Severe: 6 to 15 percent slopes
Hamar: Ha	Severe: seasonal water table.[1]	Severe: rapid permeability; seasonal water table.[1]

land use planning—Continued

Degree and kind of limitations for—Continued				
Shallow excavations	Dwellings with basements	Roads and streets	Sanitary landfill	
			Trench	Area
Slight	Moderate: low strength.	Severe: high frost action potential.	Slight	Slight.
Slight	Slight	Moderate: moderate frost action potential.	Severe: moderately rapid permeability.[1]	Severe: moderately rapid permeability.[1]
Moderate: moderately well drained.	Moderate: moderately well drained.	Moderate: moderate frost action potential.	Severe: moderately rapid permeability.[1]	Severe: moderately rapid permeability.[1]
Moderate: moderately well drained.	Moderate: moderately well drained.	Moderate: moderate frost action potential.	Slight	Slight.
Severe: poorly drained; seasonal water table; poor workability.	Severe: poorly drained; seasonal water table; high shrink-swell potential.	Severe: poorly drained; high shrink-swell potential.	Severe: poorly drained; seasonal water table; poor workability.	Severe: seasonal water table; poorly drained; subject to ponding.
Slight	Slight	Moderate: moderate frost action potential.	Slight	Slight.
Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.
Severe: poorly drained; poor workability.	Severe: poorly drained; high shrink-swell potential.	Severe: poorly drained; high shrink-swell potential.	Severe: seasonal water table; poorly drained; poor workability.	Severe: poorly drained.
Severe: somewhat poorly drained; seasonal water table; poor workability in substratum.	Severe: somewhat poorly drained; seasonal water table; high shrink-swell potential in substratum.	Severe: high shrink-swell potential in substratum.	Severe: seasonal water table; poor workability in substratum.	Severe: seasonal water table.
Moderate: moderately well drained.	Moderate: moderately well drained.	Severe: high frost action potential.	Slight	Slight.
Severe: somewhat poorly drained; seasonal water table.	Severe: somewhat poorly drained. seasonal water table.	Severe: high frost action potential.	Severe: seasonal water table.	Severe: seasonal water table.
Severe: somewhat poorly drained.	Severe: somewhat poorly drained.	Severe: high frost action potential.	Severe: seasonal water table.	Moderate: somewhat poorly drained; seasonal water table.
Severe: very poorly drained; seasonal water table; poor workability.	Severe: very poorly drained; seasonal water table; high shrink-swell potential.	Severe: very poorly drained; high shrink-swell potential.	Severe: seasonal water table; very poorly drained; poor workability; subject to ponding.	Severe: very poorly drained; subject to ponding.
Slight: 0 to 9 percent slopes. Moderate: 9 to 15 percent slopes.	Moderate: moderate shrink-swell potential; 9 to 15 percent slopes.	Severe: high frost action potential.	Moderate: silty clay loam.	Slight: 0 to 9 percent slopes. Moderate: 9 to 15 percent slopes.
Severe: poorly drained; seasonal water table.	Severe: poorly drained; seasonal water table.	Severe: poorly drained.	Severe: seasonal water table; poorly drained; rapid permeability.[1]	Severe: poorly drained; seasonal water table; rapid permeability.[1]

TABLE 7.—*Interpretations for*

Soil series and map symbols	Degree and kind of limitations for—	
	Septic tank absorption fields	Sewage lagoons
*Hamerly: Hb, Hc For Tonka parts of Hb and Hc, see Tonka series.	Severe: moderately slow permeability in substratum; seasonal water table.	Severe: seasonal water table
*Hecla: HeA, HfA, HmB For Maddock part of HmB, see Maddock series.	Slight [1]	Severe: moderately rapid and rapid permeability.[1]
*Hegne: Hn, Ho For Enloe part of Hn, see Enloe series; for Fargo part of Ho, see Fargo series.	Severe: slow permeability; seasonal water table.	Slight
*Heimdal: Hrb, Hsc For Emrick part of HrB, see Emrick series; for Esmond part of HsC, see Esmond series.	Slight	Moderate: moderate permeability; 3 to 6 percent slopes. Severe: 6 to 9 percent slopes.
LaDelle: La	Severe: subject to flooding	Moderate: moderate permeability.
Lamoure: Lm	Severe: seasonal water table; subject to flooding.	Severe: subject to flooding
Lankin: Ln	Severe: moderately slow permeability in substratum; seasonal water table.	Moderate: seasonal water table.
La Prairie: Lp	Severe: subject to flooding	Moderate: moderate permeability.
Lindaas Mapped only in complex with Bearden soils.	Severe: slow permeability; seasonal water table.	Slight
Ludden: Lu	Severe: slow permeability; seasonal water table; subject to flooding.	Severe: subject to flooding
Maddock Mapped only in complexes with Hecla and Serden soils.	Slight [1]	Severe: rapid permeability [1]
Marsh: Ma. Properties too variable for reliable interpretations.		
Nahon: Na	Severe: very slow permeability.	Slight
Nutley: NuA, NuB, NuC, NuD, NuE	Severe: slow permeability; 15 to 25 percent slopes.	Slight Moderate: 3 to 6 percent slopes. Severe: 6 to 25 percent slopes.
Ojata: Oa	Severe: slow permeability; seasonal water table.	Severe: seasonal water table

land use planning—Continued

Degree and kind of limitations for—Continued				
Shallow excavations	Dwellings with basements	Roads and streets	Sanitary landfill	
			Trench	Area
Severe: somewhat poorly drained.	Severe: somewhat poorly drained.	Severe: high frost action potential.	Severe: seasonal water table.	Moderate: somewhat poorly drained; seasonal water table.
Severe: poor sidewall stability.	Moderate: moderately well drained.	Slight	Severe: rapid permeability in substratum.[1]	Severe: rapid permeability in substratum.[1]
Severe: poorly drained; seasonal water table; poor workability.	Severe: poorly drained; seasonal water table; high shrink-swell potential.	Severe: poorly drained; high shrink-swell potential.	Severe: seasonal water table; poorly drained; poor workability.	Severe: poorly drained; seasonal water table.
Slight	Slight	Moderate: moderate frost action potential.	Slight	Slight.
Severe: subject to flooding.	Severe: subject to flooding.	Severe: high frost action potential.	Severe: subject to flooding.	Severe: subject to flooding.
Severe: seasonal water table; subject to flooding.	Severe: poorly drained; seasonal water table; subject to flooding.	Severe: poorly drained; subject to flooding.	Severe: seasonal water table; poorly drained; subject to flooding.	Severe: seasonal water table; poorly drained; subject to flooding.
Moderate: moderately well drained; seasonal water table.	Moderate: moderately well drained; moderate shrink-swell potential in substratum.	Moderate: moderate frost action potential; moderate shrink-swell potential in substratum.	Severe: seasonal water table.	Moderate: seasonal water table.
Severe: subject to flooding.	Severe: subject to flooding.	Moderate: moderate frost action potential.	Severe: subject to flooding.	Severe: subject to flooding.
Severe: poorly drained; seasonal water table.	Severe: poorly drained; seasonal water table.	Severe: poorly drained; high frost action potential.	Severe: seasonal water table; poorly drained.	Severe: seasonal water table; poorly drained.
Severe: poorly drained; seasonal water table; subject to flooding; poor workability.	Severe: poorly drained; seasonal water table; subject to flooding; high shrink-swell potential.	Severe: poorly drained; subject to flooding; high shrink-swell potential.	Severe: seasonal water table; poorly drained; subject to flooding; poor workability.	Severe: seasonal water table; poorly drained; subject to flooding.
Severe: poor sidewall stability.	Slight	Slight	Severe: rapid permeability.[1]	Severe: rapid permeability.[1]
Severe: somewhat poorly drained; poor workability in subsoil and substratum.	Severe: somewhat poorly drained; high shrink-swell potential in subsoil and substratum.	Severe: high shrink-swell potential in subsoil and substratum.	Severe: poor workability in subsoil and substratum.	Moderate: somewhat poorly drained.
Severe: poor workability; 15 to 25 percent slopes.	Severe: high shrink-swell potential; 9 to 25 percent slopes.	Severe: high shrink-swell potential.	Severe: poor workability.	Slight: 0 to 8 percent slopes. Moderate: 8 to 15 percent slopes. Severe: 15 to 25 percent slopes.
Severe: poorly drained; seasonal water table.	Severe: poorly drained; seasonal water table.	Severe: poorly drained	Severe: seasonal water table; poorly drained.	Severe: seasonal water table; poorly drained.

TABLE 7.—*Interpretations for*

Soil series and map symbols	Degree and kind of limitations for—	
	Septic tank absorption fields	Sewage lagoons
*Overly: Or, OvB For Great Bend part of OvB, see Great Bend series.	Severe: moderately slow permeability.	Slight: 0 to 3 percent slopes Moderate: 3 to 6 percent slopes.
Os For Fargo part, see Fargo series.	Severe: slow permeability in substratum.	Slight
Perella: Pe	Severe: moderately slow permeability; seasonal water table.	Slight
Playmoor: Pr	Severe: moderately slow permeability; seasonal water table; subject to flooding.	Severe: seasonal water table
Renshaw: ReA	Slight [1]	Severe: very rapid permeability in substratum.[1]
Rockwell: Ro	Severe: moderately slow permeability in substratum; seasonal water table.	Severe: seasonal water table
Ryan Mapped only in complex with Fargo soil.	Severe: very slow permeability; seasonal water table.	Slight
*Serden: SmB For Maddock part, see Maddock series.	Slight [1]	Severe: rapid permeability
*Sioux: SrB For Arvilla part, see Arvilla series.	Slight [1]	Severe: very rapid permeability in substratum.[1]
Swenoda: Sv, Sw	Severe: moderately slow permeability in substratum.	Moderate: moderately rapid permeability in surface layer and subsoil.
Tiffany: Tf	Severe: seasonal water table.[1]	Severe: seasonal water table; moderately rapid permeability.[1]
Tonka: To	Severe: slow permeability; seasonal water table.	Slight
Towner: TrA	Severe: moderately slow permeability in substratum.	Severe: rapid permeability in upper part.
Ulen: Un	Severe: seasonal water table.[1]	Severe: rapid permeability; seasonal water table.[1]

land use planning—Continued

Degree and kind of limitations for—Continued				
Shallow excavations	Dwellings with basements	Roads and streets	Sanitary landfill	
			Trench	Area
Moderate: moderately well drained.	Moderate: moderately well drained; moderate shrink-swell potential.	Severe: high frost action potential.	Moderate: moderately poor workability.	Slight.
Severe: poor workability in substratum.	Severe: high shrink-swell potential in substratum.	Severe: high frost action potential; high shrink-swell potential in substratum.	Severe: poor workability in substratum.	Slight.
Severe: poorly drained; seasonal water table.	Severe: poorly drained; seasonal water table.	Severe: poorly drained.	Severe: seasonal water table; poorly drained; subject to ponding.	Severe: seasonal water table; poorly drained.
Severe: poorly drained; seasonal water table; subject to flooding.	Severe: poorly drained; seasonal water table; subject to flooding.	Severe: poorly drained; subject to flooding.	Severe: seasonal water table; poorly drained; subject to flooding.	Severe: seasonal water table; poorly drained.
Moderate: coarse sand and gravel substratum.	Slight	Slight	Severe: very rapid permeability in substratum; coarse sand and gravel substratum.[1]	Severe: very rapid permeability in substratum; coarse sand and gravel substratum.[1]
Severe: poorly drained; seasonal water table.	Severe: poorly drained; seasonal water table.	Severe: poorly drained.	Severe: seasonal water table; poorly drained.	Severe: poorly drained; seasonal water table.
Severe: poorly drained; seasonal water table; poor workability.	Severe: poorly drained; seasonal water table; high shrink-swell potential.	Severe: poorly drained; high shrink-swell potential.	Severe: seasonal water table; poorly drained; poor workability.	Severe: seasonal water table; poorly drained.
Severe: poor sidewall stability.	Slight	Slight	Severe: rapid permeability.[1]	Severe: rapid permeability.[1]
Moderate: coarse sand and gravel substratum.	Slight	Slight	Severe: very rapid permeability in substratum; coarse sand and gravel.[1]	Severe: very rapid permeability in substratum.[1]
Moderate: moderately well drained.	Moderate: moderately well drained.	Moderate: moderate frost action potential.	Slight	Slight: needs shallow core trench.
Severe: poorly drained; seasonal water table.	Severe: poorly drained; seasonal water table.	Severe: poorly drained.	Severe: seasonal water table; poorly drained; moderately rapid permeability.[1]	Severe: seasonal water table; poorly drained; moderately rapid permeability.[1]
Severe: poorly drained; seasonal water table; poor workability in subsoil.	Severe: poorly drained; seasonal water table; high shrink-swell potential in subsoil.	Severe: poorly drained.	Severe: seasonal water table; poorly drained; poor workability in subsoil; subject to ponding.	Severe: seasonal water table; poorly drained; subject to ponding.
Moderate: moderately well drained.	Moderate: moderately well drained; moderate shrink-swell potential in substratum.	Moderate: shrink-swell in substratum; frost action potential.	Severe: seasonal water table; rapid permeability in upper part.	Severe: rapid permeability in upper part.
Severe: somewhat poorly drained; seasonal water table; poor sidewall stability.	Severe: somewhat poorly drained; seasonal water table.	Moderate: moderate frost action potential.	Severe: seasonal water table; rapid permeability.[1]	Severe: seasonal water table; rapid permeability.[1]

TABLE 7.—*Interpretations for*

Soil series and map symbols	Degree and kind of limitations for—	
	Septic tank absorption fields	Sewage lagoons
*Vallers: Vd For Doran part, see Doran series.	Severe: moderately slow permeability; seasonal water table.	Severe: seasonal water table
Viking: Vk	Severe: very slow permeability; seasonal water table.	Slight
Wahpeton: WaA	Severe: subject to flooding	Moderate: moderate permeability.
Wheatville: Wn	Severe: slow permeability in substratum; seasonal water table.	Slight: needs shallow core trench.
Wyndmere: Wn, Wo, Ws, Wt For Tiffany part of Wt, see Tiffany series.	Severe: seasonal water table.[1]	Severe: moderately rapid permeability; seasonal water table.[1]
Zell: ZeE	Moderate: 9 to 15 percent slopes. Severe: 15 to 25 percent slopes.	Severe: slope

[1] Pollution is a hazard in places because of moderately rapid to very rapid permeability in substratum.

or organic material in a soil are among factors that are unfavorable.

Drainage for crops and pasture is affected by such soil properties as permeability, texture, and structure; depth to claypan, rock, or other layers that influence rate of water movement; depth to water table; slope stability in ditchbanks; susceptibility to stream overflow; salinity or alkalinity; and availability of outlets for drainage.

Irrigation of a soil is affected by slope; susceptibility to flooding by streams, water erosion, or soil blowing; soil texture; content of stones; salinity or alkalinity; depth of the root zone; rate of water intake at the surface; permeability of soil layers below the surface layer and in a claypan or other layer that restricts movement of water; amount of water available to plants; and need for drainage or depth to water table or bedrock.

Terraces and diversions are embankments or ridges constructed across the slope to intercept runoff so that it soaks into the soil or flows slowly to a prepared outlet. Features that affect suitability are uniformity of slope and steepness; depth to bedrock or other unfavorable material; presence of stones; permeability; and resistance to water erosion, soil slipping, and soil blowing. A soil suitable for these structures provides outlets for runoff and is not difficult to vegetate.

Grassed waterways are natural or artificial water courses that are seeded to grasses for water erosion protection. Features that affect suitability are erodibility of soil material; texture and thickness of soil layers; natural drainage; presence of stones; steepness of slope; potential for siltation of channels, including accumulation from soil blowing; available water capacity; and presence of seepage areas.

Formation and Classification of the Soils

This section describes the major factors of soil formation and how they relate to the soils of Traill County. It also defines the system of soil classification currently used and shows how the soils of the county are classified according to the current system.

Factors of Soil Formation

Soil is produced by soil-forming processes acting on materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by the physical and mineralogical composition of the parent material; the climate under which the soil material has accumulated and existed

land use planning—Continued

Degree and kind of limitations for—Continued				
Shallow excavations	Dwellings with basements	Roads and streets	Sanitary landfill	
			Trench	Area
Severe: poorly drained; seasonal water table.	Severe: poorly drained; seasonal water table.	Severe: high frost action potential.	Severe: seasonal water table; poorly drained.	Severe: seasonal water table; poorly drained.
Severe: poorly drained; seasonal water table; poor workability.	Severe: poorly drained; seasonal water table; high shrink-swell potential.	Severe: poorly drained; high shrink-swell potential.	Severe: seasonal water table; poorly drained; poor workability.	Severe: seasonal water table; poorly drained.
Severe: subject to flooding; poor workability.	Severe: subject to flooding; high shrink-swell potential.	Severe: subject to flooding; high shrink-swell potential.	Severe: subject to flooding; poor workability.	Severe: subject to flooding.
Severe: somewhat poorly drained; seasonal water table; poor workability in substratum.	Severe: somewhat poorly drained; seasonal water table; high shrink-swell potential in substratum.	Severe: high frost action potential; high shrink-swell potential in substratum.	Severe: seasonal water table; poor workability in substratum.	Severe: seasonal water table.
Severe: somewhat poorly drained; seasonal water table.	Severe: somewhat poorly drained.	Severe: high frost action potential.	Severe: seasonal water table; moderately rapid permeability.[1]	Severe: seasonal water table; moderately rapid permeability.[1]
Moderate: 9 to 15 percent slopes. Severe: 15 to 25 percent slopes.	Moderate: 9 to 15 percent slopes. Severe: 15 to 25 percent slopes.	Moderate: 9 to 15 percent slopes. Severe: 15 to 25 percent slopes.	Slight: 6 to 15 percent slopes. Moderate: 15 to 25 percent slopes.	Slight: 6 to 9 percent slopes. Moderate: 9 to 15 percent slopes. Severe: 15 to 25 percent slopes.

since accumulation; the plant and animal life on and in the soil; the relief, or lay of the land; and the length of time the forces of soil formation have acted on the soil material.

Climate and plant and animal life, chiefly plants, are active factors of soil formation. They act on the parent material that has accumulated through the weathering of rocks and slowly change it to a natural body that has genetically related horizons. The effect of climate and plant and animal life is conditioned by relief. The parent material also affects the kind of soil profile that is formed and, in extreme cases, determines it almost entirely. Finally, time is needed for changing the parent material into a soil profile. It may be much or little, but some time is always required for differentiation of soil horizons. Usually, a long time is required for the development of distinct horizons.

The factors of soil formation are so closely interrelated that few generalizations can be made regarding the effect of any one factor unless conditions are specified for the other four. Many of the processes of soil development are unknown.

Parent material

During the Pleistocene period all of Traill County was covered by glacier. As the last glacier receded, Glacial Lake Agassiz formed and covered all of the county, except the extreme southwestern corner where the Drift Prairie begins and extends westward. The parent material of soils in this county consists mainly of glacial lacustrine deposits, glacial melt-water deposits, glacial till, post-glacial alluvium, and sand and gravel deposits.

Mainly in the eastern and central parts of the county, glacial lacustrine deposits are generally toward the center of Glacial Lake Agassiz where the water was deepest. The deposits, carried out into the glacial lake by glacial melt water, settled on the lake bottom. They consist of well sorted silt and clay about 3 to 80 feet thick that are commonly laminated, varved or banded, and cohesive, but few pebbles and little sand. Generally in the eastern part of the county are thicker glacial lacustrine deposits and, with increasing distance westward, thinner lacustrine deposits. In soil associations 1, 2, 3, and 4 shown on the General Soil Map, most of the soils formed in glacial lacustrine deposits.

Mainly in the western and central parts of the county, generally in the shallow parts of Glacial Lake Agassiz, are glacial melt-water deposits. These deposits consist of silt and sand about 3 to 150 feet thick that are commonly cross-bedded and loose, small amounts of clay, and little or no gravel. Generally in the western part of the county are thicker glacial

TABLE 8.—*Interpretations of*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. The as indicated in the first

Soil series and map symbols	Suitability as a source of—			
	Cover material for sanitary landfill	Roadfill	Sand and gravel	Topsoil
Arveson: Ar, As	Poor: poorly drained.	Poor: poorly drained.	Fair for sand: fines. Unsuitable for gravel.	Poor: poorly drained.
Arvilla: AvB	Poor: suitable material less than 20 inches thick.	Good	Good for sand. Fair for gravel.	Poor: shallow and moderately deep to sand and gravel.
*Bearden: Bd	Fair: moderate salinity.	Poor: high frost action potential.	Unsuitable	Fair: moderate salinity.
Be, Bn, Bo, Bp, Bs. For Lindaas part of Bn, see Lindaas series; for Overly part of Bo, see Overly series; for Perella part of Bp, see Perella series; for Glyndon part of Bs, see Glyndon series.	Good: silt loam. Fair: silty clay loam.	Poor: high frost action potential.	Unsuitable	Fair: less than 16 inches of suitable material.
Bq	Fair: silty clay loam.	Poor: high frost action potential; high shrink-swell potential in substratum.	Unsuitable	Fair: silty clay loam.
Beotia: Bt	Good	Fair: moderate shrink-swell potential.	Unsuitable	Good
*Bohnsack: Bu, Bv. For Tiffany part of Bv, see Tiffany series.	Good	Poor: high frost action potential.	Unsuitable	Fair: less than 16 inches of suitable material.
Borup: Bw	Poor: poorly drained.	Poor: poorly drained.	Unsuitable	Poor: poorly drained.

engineering properties of the soils

soils in such mapping units may have different properties and limitations, and for this reason it is necessary to refer to other series column of this table]

Soil features affecting—					
Pond reservoir areas	Embankments, dikes, and levees	Drainage for crops and pasture	Irrigation	Terraces and diversions	Grassed waterways
Seasonal water table; moderately rapid permeability. 0 to 1 percent slopes.	Medium to high susceptibility to piping; low to medium compressibility; fair to good compaction characteristics.	Seasonal water table; moderately rapid permeability; subject to ponding; 0 to 1 percent slopes.	Moderate available water capacity; seasonal water table; needs drainage; moderately rapid intake.	Not needed	Not needed.
Very rapid permeability in substratum; shallow and moderately deep to sand and gravel.	Medium to high shear strength; low to medium compressibility; fair to good compaction characteristics; high to low permeability of compacted material.	Not needed	Very rapid permeability in substratum; low available water capacity; 1 to 6 percent slopes.	Shallow and moderately deep to sand and gravel; highly erodible; difficult to vegetate; 1 to 6 percent slopes.	Shallow and moderately deep to sand and gravel; highly erodible; low available water capacity; difficult to vegetate.
Moderately slow permeability; seasonal water table; 0 to 1 percent slopes.	Medium to low shear strength; medium compressibility; fair to good compaction characteristics.	Seasonal water table; moderately slow permeability; 0 to 1 percent slopes; moderate salinity.	Moderately slow permeability; seasonal water table; moderate salinity	0 to 1 percent slopes; difficult to vegetate; moderate salinity.	Nearly level; moderate salinity; difficult to vegetate.
Moderately slow permeability; seasonal water table; 0 to 1 percent slopes.	Medium to low shear strength; medium compressibility; fair to good compaction characteristics.	Seasonal water table; moderately slow permeability; 0 to 1 percent slopes.	Moderately slow permeability; seasonal water table.	0 to 1 percent slopes; silty clay loam and silt loam; moderately slow permeability.	All features favorable.
Slow permeability in substratum; seasonal water table; 0 to 1 percent slopes.	Medium to low shear strength in substratum; high compressibility; fair to poor compaction characteristics.	Slow permeability in substratum; seasonal water table; 0 to 1 percent slopes.	Slow permeability in substratum; seasonal water table.	0 to 1 percent slopes; poor workability and slow permeability in substratum.	Nearly level; poor workability in substratum.
Moderate permeability; 0 to 1 percent slopes.	Medium to low shear strength; medium compressibility; fair to poor compaction characteristics.	Not needed	0 to 1 percent slopes; high available water capacity; moderate permeability.	All soil features favorable.	Nearly level; all soil features favorable.
Moderate permeability; seasonal water table; 0 to 1 percent slopes.	Medium to low shear strength; medium compressibility; medium to low permeability of compacted soil; medium to high susceptibility to piping.	Moderate permeability; seasonal water table; 0 to 1 percent slopes.	Moderate permeability; seasonal water table; needs drainage.	0 to 1 percent slopes; moderate permeability; few stones; moderately susceptible to soil blowing.	0 to 1 percent slopes; few stones.
Moderately rapid permeability in substratum; seasonal water table; 0 to 1 percent slopes.	Medium to low shear strength; susceptible to piping; fair to poor compaction characteristics.	Seasonal water table; moderately rapid permeability in substratum; subject to ponding; 0 to 1 percent slopes.	Needs drainage; seasonal water table; moderately rapid permeability in substratum.	Not needed	Not needed.

TABLE 8.—*Interpretations of engineering*

Soil series and map symbols	Suitability as a source of—			
	Cover material for sanitary landfill	Roadfill	Sand and gravel	Topsoil
Borup—Continued Bx	Poor: poorly drained.	Poor: poorly drained.	Unsuitable	Poor: poorly drained.
Cashel: CaA, CaC	Poor: poor workability.	Poor: high shrink-swell potential.	Unsuitable	Poor: silty clay
Colvin: Co	Poor: poorly drained.	Poor: poorly drained.	Unsuitable	Poor: poorly drained.
Cs	Poor: poorly drained.	Poor: poorly drained.	Unsuitable	Poor: poorly drained.
Cut and fill land: Cu. Properties too variable for reliable interpretations.				
Divide: Dd	Fair: suitable material 20 to 40 inches thick.	Fair: somewhat poorly drained.	Poor: fines	Fair: less than 16 inches of suitable material.
Doran: Do	Fair: clay loam; thin layer of clay in upper 2 feet.	Poor: high frost action potential.	Unsuitable	Fair: clay loam
Dovray: Dv	Poor: poorly drained and very poorly drained; poor workability.	Poor: poorly drained and very poorly drained; high shrink-swell potential.	Unsuitable	Poor: poorly drained and very poorly drained; clayey.
Eckman Mapped only in complex with Gardena soils.	Good	Poor: high frost action potential.	Unsuitable	Good

properties of the soils—Continued

Soil features affecting—					
Pond reservoir areas	Embankments, dikes, and levees	Drainage for crops and pasture	Irrigation	Terraces and diversions	Grassed waterways
Moderately rapid permeability in substratum; seasonal water table; 0 to 1 percent slopes.	Medium to low shear strength; susceptible to piping; fair to poor compaction characteristics.	Seasonal water table; moderate salinity; subject to ponding; 0 to 1 percent slopes; moderately rapid permeability in substratum.	Seasonal water table; needs drainage; moderate salinity; moderately rapid permeability in substratum.	Not needed	Not needed.
Moderately slow permeability.	Medium to low shear strength; high compressibility; fair to poor compaction characteristics.	Moderately slow permeability; subject to flooding; poor workability.	Moderately slow permeability; subject to stream overflow.	Clayey materials; construction difficult; 1 to 9 percent slopes; subject to flooding.	Not needed.
Moderate and moderately slow permeability; seasonal water table; 0 to 1 percent slopes.	Medium to low shear strength; medium compressibility; fair to good compaction characteristics.	Seasonal water table; moderate and moderately slow permeability; subject to ponding; 0 to 1 percent slopes.	Moderate and moderately slow permeability; seasonal water table; moderate salinity; needs drainage.	Not needed	Not needed.
Moderate and moderately slow permeability; seasonal water table; 0 to 1 percent slopes.	Medium to low shear strength; medium compressibility; fair to good compaction characteristics.	Seasonal water table; moderate and moderately slow permeability; moderate salinity; subject to ponding; 0 to 1 percent slopes.	Moderate and moderately slow permeability; seasonal water table; moderate salinity; needs drainage.	Not needed	Not needed.
Very rapid permeability in substratum; seasonal water table; moderately deep to coarse sand and gravel.	High to medium shear strength; low to medium compressibility; fair to good compaction characteristics.	Very rapid permeability in substratum; seasonal water table; 0 to 1 percent slopes.	Low available water capacity; seasonal water table; very rapid permeability in substratum.	Not needed	Not needed.
Moderately slow and slow permeability; 0 to 1 percent slopes.	Medium to high compressibility; low permeability of compacted soil; fair to good compaction characteristics.	Seasonal water table; moderately slow and slow permeability; 0 to 1 percent slopes.	Moderately slow and slow permeability; seasonal water table.	0 to 1 percent slopes; moderately slow and slow permeability; clayey subsoil; construction difficult.	Not needed.
Very slow permeability; seasonal water table; 0 to 1 percent slopes; subject to ponding.	Medium to low shear strength; high compressibility; fair to poor compaction characteristics.	Very slow permeability; silty clay and clay; seasonal water table; 0 to 1 percent slopes; subject to ponding.	Very low permeability; needs drainage; seasonal water table.	Not needed	Not needed.
Moderate permeability; 3 to 6 percent slopes.	Medium to low shear strength; medium compressibility; high susceptibility to piping.	Not needed	Moderate permeability; high available water capacity; 3 to 6 percent slopes.	Short; 3 to 6 percent slopes; moderately erodible; high susceptibility to piping.	Moderately erodible; 3 to 6 percent slopes.

TABLE 8.—*Interpretations of engineering*

Soil series and map symbols	Suitability as a source of—			
	Cover material for sanitary landfill	Roadfill	Sand and gravel	Topsoil
*Egeland: EdA, EgA, EgB For Embden parts of EgA and EgB, see Embden series.	Good	Fair: moderate frost action potential.	Poor for sand: many fines. Unsuitable for gravel.	Good
Embden: Em, En	Good	Fair: moderate frost action potential.	Poor for sand: many fines. Unsuitable for gravel.	Good
*Emrick:				
Eo	Good	Fair: moderate frost action potential.	Unsuitable	Good
EpA For Heimdal part, see Heimdal series.	Good	Fair: moderate frost action potential.	Unsuitable	Good
Enloe Mapped only in complexes with Fargo and Hegne soils.	Poor: poorly drained.	Poor: high shrink-swell potential; poorly drained.	Unsuitable	Poor: poorly drained.
Esmond Mapped only in complex with Heimdal soils.	Good	Fair: moderate frost action potential.	Unsuitable	Fair: less than 16 inches of suitable material.
Fairdale: FaA	Good	Fair: moderate frost action potential; moderate shrink-swell potential.	Unsuitable	Good
*Fargo: Fb, Fc, Fd, Fe, Fg, Fn, Fn For Dovray part of Fd, see Dovray series; for Enloe parts of Fe and Fg see Enloe series; for Hegne part of Fh, see Hegne series; for Ryan part of Fn, see Ryan series.	Poor: poorly drained; poor workability.	Poor: high shrink-swell potential; poorly drained.	Unsuitable	Poor: poorly drained; silty clay.
*Galchutt: Ga For Fargo part, see Fargo series.	Fair: silty clay loam; suitable material 20 to 40 inches thick.	Poor: high frost action potential; high shrink-swell potential in substratum.	Unsuitable	Good if silt loam. Fair if silty clay loam.

properties of the soils—Continued

Soil features affecting—					
Pond reservoir areas	Embankments, dikes, and levees	Drainage for crops and pasture	Irrigation	Terraces and diversions	Grassed waterways
Moderately rapid permeability; 1 to 6 percent slopes.	Medium to low shear strength; low to medium compressibility; medium to high susceptibility to piping.	Not needed	Moderately rapid permeability; moderate available water capacity; 1 to 6 percent slopes; severely susceptible to soil blowing.	1 to 6 percent slopes; susceptible to soil blowing; moderately rapid permeability.	Susceptible to soil blowing; moderate available water capacity.
Moderately rapid permeability; 0 to 6 percent slopes.	Medium to low shear strength; low to medium compressibility; medium to high susceptibility to piping.	Not needed	Moderately rapid permeability; moderate available water capacity; 0 to 6 percent slopes; severely susceptible to soil blowing.	0 to 6 percent slopes; susceptible to soil blowing; moderately rapid permeability.	Susceptible to soil blowing; moderate available water capacity.
Moderate permeability; 0 to 1 percent slopes.	Medium to low shear strength; medium compressibility; fair to poor compaction characteristics.	Not needed	Moderate permeability; high available water capacity; 0 to 1 percent slopes.	0 to 1 percent slopes; moderate permeability.	Susceptible to soil blowing; high available water capacity.
Moderate permeability; 1 to 6 percent slopes.	Medium to low shear strength; medium compressibility; fair to poor compaction characteristics.	Not needed	1 to 6 percent slopes; high available water capacity; moderate permeability.	1 to 6 percent slopes; slightly and moderately erodible; moderate permeability.	Susceptible to soil blowing; high available water capacity; difficult to vegetate; erodible.
Slow permeability; seasonal water table; 0 to 1 percent slopes; subject to ponding.	Medium to low shear strength; high compressibility; fair to poor compaction characteristics.	Slow permeability; seasonal water table; 0 to 1 percent slopes; subject to ponding.	Slow permeability; seasonal water table; needs drainage.	0 to 1 percent slopes; clayey; slow permeability; construction difficult.	Not needed.
Moderate permeability; 6 to 9 percent slopes.	Medium to low shear strength; medium compressibility; fair to poor compaction characteristics; medium to high susceptibility to piping.	Not needed	High available water capacity; 6 to 9 percent slopes; moderate permeability; severe hazard of water erosion.	Short; 6 to 9 percent slopes; severe hazard of water erosion; moderate permeability.	Severe hazard of water erosion; 6 to 9 percent slopes; high available water capacity.
Moderate permeability; 1 to 3 percent slopes.	Medium to low shear strength; medium compressibility; fair compaction characteristics.	Moderate permeability; subject to flooding.	Moderate permeability; high available water capacity; 1 to 3 percent slopes; subject to stream overflow.	1 to 3 percent slopes; subject to flooding.	Not needed.
Slow permeability; 0 to 1 percent slopes; seasonal water table.	Medium to low shear strength; high compressibility; fair to poor compaction characteristics.	Slow permeability; silty clay; 0 to 1 percent slopes; subject to ponding in places.	Slow permeability; 0 to 1 percent slopes; seasonal water table.	0 to 1 percent slopes; clayey; slow permeability; poor workability.	Not needed.
Slow permeability in substratum; 0 to 1 percent slopes; seasonal water table.	Medium to low shear strength; high to medium compressibility; fair to poor compaction characteristics.	Slow permeability and clay in substratum; seasonal water table; 0 to 1 percent slopes.	High available water capacity; 0 to 1 percent slopes; seasonal water table; slow permeability in substratum.	0 to 1 percent slopes; slow permeability and clayey in substratum.	Not needed.

TABLE 8.—*Interpretations of engineering*

Soil series and map symbols	Suitability as a source of—			
	Cover material for sanitary landfill	Roadfill	Sand and gravel	Topsoil
*Gardena: Gd, GeB, GfC For Eckman part of GeB, see Eckman series; for Zell part of GfC, see Zell series.	Good	Poor: high frost action potential.	Unsuitable	Good
*Gilby: Gg, Gh For Tonka part of Gh, see Tonka series.	Fair: suitable material 20 to 40 inches thick; few stones.	Poor: high frost action potential.	Unsuitable	Fair: less than 16 inches of suitable material.
Gk For Tonka part, see Tonka series.	Fair: suitable material 20 to 40 inches thick; few stones; moderate salinity.	Poor: high frost action potential.	Unsuitable	Fair: moderate salinity; less than 16 inches of suitable material.
*Glyndon: Gm, Go For Perella part of Go, see Perella series.	Good	Poor: high frost action potential.	Unsuitable	Fair: less than 16 inches of suitable material.
Gn	Fair: moderate salinity.	Poor: high frost action potential.	Unsuitable	Fair: moderate salinity; less than 16 inches of suitable material.
Gr For Tiffany part, see Tiffany series.	Good	Poor: high frost action potential.	Unsuitable	Fair: less than 16 inches of suitable material.
Grano: Gs	Poor: very poorly drained; poor workability.	Poor: high shrink-swell potential; very poorly drained.	Unsuitable	Poor: silty clay; very poorly drained.
Great Bend: GwA, GwC, GwD	Fair: silty clay loam; 9 to 15 percent slopes.	Poor: high frost action potential.	Unsuitable	Fair: silty clay loam.

properties of the soils—Continued

Soil features affecting—					
Pond reservoir areas	Embankments, dikes, and levees	Drainage for crops and pasture	Irrigation	Terraces and diversions	Grassed waterways
Moderate permeability; 0 to 9 percent slopes.	Medium to low shear strength; medium compressibility; high susceptibility to piping; fair to poor compaction characteristics.	Not needed	High available water capacity; moderate permeability; 0 to 9 percent slopes.	0 to 9 percent slopes; moderate and severe hazard of erosion; moderate permeability.	Moderate and severe hazard of erosion; high available water capacity.
Moderately slow permeability in substratum; seasonal water table; 0 to 1 percent slopes.	Medium to low shear strength; medium compressibility; fair to good compaction characteristics in substratum.	Moderately slow permeability in substratum; seasonal water table; 0 to 1 percent slopes.	Moderately slow permeability in substratum; seasonal water table; 0 to 1 percent slopes.	0 to 1 percent slopes; moderately slow permeability in substratum; upper part erodible.	Not needed.
Moderately slow permeability in substratum; seasonal water table; 0 to 1 percent slopes.	Medium to low shear strength; medium compressibility; fair to good compaction characteristics in substratum.	Moderately slow permeability in substratum; seasonal water table; 0 to 1 percent slopes; moderate salinity.	Moderately slow permeability in substratum; seasonal water table; moderate salinity; 0 to 1 percent slopes.	0 to 1 percent slopes; moderately slow permeability in substratum; moderate salinity; difficult to vegetate.	Not needed.
Moderate permeability; seasonal water table; 0 to 1 percent slopes.	Medium to low shear strength; medium compressibility; high susceptibility to piping; fair to good compaction characteristics.	Moderate permeability; seasonal water table; 0 to 1 percent slopes.	Moderate permeability; seasonal water table; 0 to 1 percent slopes.	0 to 1 percent slopes; moderate permeability; moderately susceptible to soil blowing.	0 to 1 percent slopes; cuts erodible unless vegetated.
Moderate permeability; seasonal water table; 0 to 1 percent slopes.	Medium to low shear strength; medium compressibility; high susceptibility to piping; fair to poor compaction characteristics.	Moderate permeability; seasonal water table; 0 to 1 percent slopes; moderate salinity.	Moderate permeability; seasonal water table; 0 to 1 percent slopes; moderate salinity.	0 to 1 percent slopes; moderate permeability; moderately susceptible to soil blowing; moderate salinity; difficult to vegetate.	0 to 1 percent slopes; moderate salinity; cuts erodible unless vegetated; difficult to vegetate.
Moderate permeability; seasonal water table; 0 to 1 percent slopes.	Medium to low shear strength; medium compressibility; high to medium susceptibility to piping; fair to poor compaction characteristics.	Moderate permeability; seasonal water table; 0 to 1 percent slopes.	Moderate permeability; seasonal water table; 0 to 1 percent slopes.	0 to 1 percent slopes; moderate permeability; moderately susceptible to soil blowing.	0 to 1 percent slopes; cuts erodible unless vegetated.
Slow permeability; seasonal water table; 0 to 1 percent slopes.	Medium to low shear strength; high compressibility; fair to poor compaction characteristics.	Slow permeability; silty clay; seasonal water table; subject to ponding; 0 to 1 percent slopes; availability of outlets.	Slow permeability; needs drainage; seasonal water table.	Not needed	Not needed.
Moderate permeability; 1 to 15 percent slopes.	Medium to low shear strength; medium compressibility; fair to good compaction characteristics.	Not needed	Moderate permeability; high available water capacity; 1 to 15 percent slopes; severe hazard of water erosion on steeper slopes.	1 to 15 percent slopes; slight to very severe hazard of water erosion; moderate permeability.	1 to 15 percent slopes; slight to very severe hazard of water erosion.

TABLE 8.—*Interpretations of engineering*

Soil series and map symbols	Suitability as a source of—			
	Cover material for sanitary landfill	Roadfill	Sand and gravel	Topsoil
Hamar: Ha	Poor: poorly drained.	Poor: poorly drained.	Fair for fine sand: fines. Unsuitable for gravel.	Poor: poorly drained.
*Hamerly: Hb. For Tonka part, see Tonka series.	Fair: clay loam; few stones.	Poor: high frost action potential.	Unsuitable	Fair: clay loam
Hc. For Tonka part, see Tonka series.	Fair: clay loam; moderate salinity.	Poor: high frost action potential.	Unsuitable	Fair: clay loam; moderate salinity.
*Hecla: HeA, HfA, HmB. For Maddock part of HmB, see Maddock series.	Fair: thickness of material; loamy fine sand.	Good	Fair for fine sand: fines. Unsuitable for gravel.	Good if fine sandy loam. Poor if loamy fine sand.
*Hegne: Hn, Ho. For Enloe part of Hn, see Enloe series; for Fargo part of Ho see Fargo series.	Poor: poorly drained; poor workability.	Poor: high shrink-swell potential; poorly drained.	Unsuitable	Poor: silty clay
*Heimdal: HrB, HsC. For Emrick part of HrB, see Emrick series; for Esmond part of HsC, see Esmond series.	Good	Fair: moderate frost action potential.	Unsuitable	Good
LaDelle: La	Fair: silty clay loam.	Poor: high frost action potential.	Unsuitable	Fair: silty clay loam.
Lamoure: Lm	Poor: poorly drained.	Poor: poorly drained.	Unsuitable	Poor: poorly drained.

properties of the soils—Continued

Soil features affecting—					
Pond reservoir areas	Embankments, dikes, and levees	Drainage for crops and pasture	Irrigation	Terraces and diversions	Grassed waterways
Rapid permeability; seasonal water table; 0 to 1 percent slopes.	Medium to low shear strength; low to medium compressibility; medium to high susceptibility to piping; fair to good compaction characteristics.	Rapid permeability; seasonal water table; 0 to 1 percent slopes; subject to ponding.	Low available water capacity; rapid permeability; seasonal water table; needs drainage.	0 to 1 percent slopes; severely susceptible to soil blowing; moderately rapid and rapid permeability; sandy.	Not needed.
Moderately slow permeability in substratum; seasonal water table; 0 to 1 percent slopes.	Medium to low shear strength; medium compressibility; low to medium susceptibility to piping; fair to good compaction characteristics.	Moderately slow permeability in substratum; seasonal water table; 0 to 1 percent slopes.	Moderately slow permeability in substratum; seasonal water table; salinity in substratum.	0 to 1 percent slopes; susceptible to soil blowing; cuts difficult to vegetate; moderately slow permeability in substratum.	Susceptible to soil blowing; cuts difficult to vegetate.
Moderately slow permeability in substratum; seasonal water table; 0 to 1 percent slopes.	Medium to low shear strength; medium compressibility; low to medium susceptibility to piping; fair to good compaction characteristics.	Moderately slow permeability in substratum; seasonal water table; 0 to 1 percent slopes; moderate salinity.	Moderately slow permeability in substratum; seasonal water table; moderate salinity.	0 to 1 percent slopes; susceptible to soil blowing; difficult to vegetate; moderately slow permeability in substratum.	Difficult to vegetate; susceptible to soil blowing.
Moderately rapid and rapid permeability; 1 to 6 percent slopes.	Medium to low shear strength; low to medium compressibility; medium to high susceptibility to piping; fair to good compaction characteristics.	Not needed	Low available water capacity; 1 to 6 percent slopes; severely and very severely susceptible to soil blowing; moderately rapid and rapid permeability.	1 to 6 percent slopes; moderately rapid and rapid permeability; severely and very severely susceptible to soil blowing.	1 to 6 percent slopes; susceptible to soil blowing; high potential for windblown accumulations.
Slow permeability; seasonal water table; 0 to 1 percent slopes.	Medium to low shear strength; high compressibility; fair to poor compaction characteristics.	Slow permeability; seasonal water table; 0 to 1 percent slopes; silty clay.	Slow permeability; seasonal water table; 0 to 1 percent slopes.	0 to 1 percent slopes; slow permeability; poor workability; moderately susceptible to soil blowing.	Not needed.
Moderate permeability; 1 to 9 percent slopes.	Medium to low shear strength; medium compressibility; fair to poor compaction characteristics.	Not needed	Moderate permeability; high available water capacity; 1 to 9 percent slopes; moderately susceptible to soil blowing.	1 to 9 percent slopes; moderate permeability; moderately susceptible to soil blowing.	1 to 9 percent slopes; severe hazard of water erosion on steeper slopes; high silting potential.
Moderate permeability; 0 to 1 percent slopes.	Medium to low shear strength; medium compressibility; fair to good compaction characteristics.	Not needed	High available water capacity; moderate permeability; 0 to 1 percent slopes.	Not needed	Not needed.
Moderate permeability; seasonal water table; 0 to 1 percent slopes.	Medium to low shear strength; medium compressibility; fair to good compaction characteristics.	Moderate permeability; seasonal water table; 0 to 1 percent slopes; subject to flooding.	Moderate permeability; seasonal water table; needs drainage; 0 to 1 percent slopes; subject to stream overflow.	Not needed	Not needed.

TABLE 8.—*Interpretations of engineering*

Soil series and map symbols	Suitability as a source of—			
	Cover material for sanitary landfill	Roadfill	Sand and gravel	Topsoil
Lankin: Ln	Good	Fair: moderate frost action potential.	Unsuitable	Good
La Prairie: Lp	Good	Fair: moderate frost action potential.	Unsuitable	Good
Lindaas Mapped only in complex with Bearden soils.	Poor: poorly drained.	Poor: poorly drained; high frost action potential.	Unsuitable	Poor: poorly drained.
Ludden: Lu	Poor: poorly drained; poor workability.	Poor: poorly drained: high shrink-swell potential.	Unsuitable	Poor: poorly drained; silty clay.
Maddock Mapped only in complexes with Hecla and Serden soils.	Fair: loamy sand	Good	Fair for sand: fines. Unsuitable for gravel.	Fair: less than 16 inches of suitable material. Poor if loamy sand
Marsh: Ma. Properties too variable for reliable interpretations.				
Nahon: Na	Poor: thickness of suitable material.	Poor: high shrink-swell potential in subsoil and substratum.	Unsuitable	Fair: less than 16 inches of suitable material.
Nutley: NuA, NuB, NuC, NuD, NuE	Poor: poor workability.	Poor: high shrink-swell potential.	Unsuitable	Poor: silty clay
Ojata: Oa	Poor: poorly drained; strong salinity.	Poor: poorly drained; strong salinity.	Unsuitable	Poor: strong salinity.

properties of the soils—Continued

Soil features affecting—					
Pond reservoir areas	Embankments, dikes, and levees	Drainage for crops and pasture	Irrigation	Terraces and diversions	Grassed waterways
Moderately slow permeability in substratum; seasonal water table; 0 to 1 percent slopes.	Medium to low shear strength; medium compressibility; fair to good compaction characteristics.	Not needed	0 to 1 percent slopes; seasonal water table; moderately slow permeability in substratum.	Not needed	All features favorable.
Moderate permeability; 0 to 1 percent slopes.	Medium to low shear strength; medium compressibility; fair to good compaction characteristics.	Not needed	High available water capacity; 0 to 1 percent slopes; moderate permeability; subject to stream overflow.	Not needed	Not needed.
Slow permeability; 0 to 1 percent slopes; seasonal water table.	Medium to low shear strength; medium and high compressibility; poor to good compaction characteristics.	Slow permeability in substratum; seasonal water table; subject to ponding; 0 to 1 percent slopes.	High available water capacity; seasonal water table; needs drainage; slow permeability.	Not needed	Not needed.
Slow permeability; seasonal water table; 0 to 1 percent slopes.	Medium to low shear strength; high compressibility; fair to poor compaction characteristics.	Slow permeability; silty clay; seasonal water table; subject to flooding; 0 to 1 percent slopes.	High available water capacity; slow permeability; seasonal water table; subject to stream overflow; needs drainage.	Poor workability; poor drainage; slow permeability.	Not needed.
Rapid permeability; 1 to 6 percent slopes.	Medium shear strength; low to medium compressibility; medium to high susceptibility to piping; fair to good compaction characteristics.	Not needed	Rapid permeability; low available water capacity; 1 to 6 percent slopes; severely and very severely susceptible to soil blowing.	1 to 6 percent slopes; susceptible to soil blowing; rapid permeability.	Susceptible to soil blowing; high potential for windblown accumulations.
Very slow permeability; 0 to 1 percent slopes.	Medium to low shear strength; high compressibility; fair to poor compaction characteristics.	Very slow permeability; claypan subsoil; 0 to 1 percent slopes.	Moderate available water capacity; very slow permeability; claypan subsoil.	0 to 1 percent slopes; shallow to claypan; very slow permeability.	Not needed.
Slow permeability; 1 to 25 percent slopes.	Medium to low shear strength; high compressibility; fair to poor compaction characteristics.	Not needed	High available water capacity; 1 to 25 percent slopes; slow permeability; severe hazard of water erosion on steeper slopes.	Short; 1 to 25 percent slopes; poor workability; severe hazard of water erosion on steeper slopes.	Severe hazard of water erosion on steeper slopes; 1 to 25 percent slopes; moderately susceptible to soil blowing.
Slow permeability; seasonal water table; 0 to 1 percent slopes.	Medium to low shear strength; medium compressibility; medium to high susceptibility to piping; fair to poor compaction characteristics.	Slow permeability; seasonal water table; strong salinity; availability of outlets; 0 to 1 percent slopes; subject to ponding.	Moderate available water capacity; seasonal water table; strong salinity; needs drainage; slow permeability.	Not needed	0 to 1 percent slopes; seasonal water table; difficult to vegetate.

TABLE 8.—*Interpretations of engineering*

Soil series and map symbols	Suitability as a source of—			
	Cover material for sanitary landfill	Roadfill	Sand and gravel	Topsoil
*Overly: Or, OvB For Great Bend part of OvB, see Great Bend series.	Fair: moderately poor workability.	Poor: high frost action potential.	Unsuitable	Fair: silty clay loam.
Os For Fargo part, see Fargo series.	Fair: thickness of material; silty clay loam.	Poor: high frost action potential; high shrink-swell potential in substratum.	Unsuitable	Fair: silty clay loam.
Perella: Pe	Poor: poorly drained.	Poor: poorly drained.	Unsuitable	Poor: poorly drained.
Playmoor: Pr	Poor: poorly drained.	Poor: poorly drained.	Unsuitable	Poor: poorly drained.
Renshaw: ReA	Poor: thickness of material.	Good	Good for gravel and sand.	Poor: shallow to gravel.
Rockwell: Ro	Fair: clay material between 20 and 40 inches.	Poor: poorly drained.	Unsuitable	Fair: less than 16 inches of suitable material.
Ryan Mapped only in complex with Fargo soil.	Poor: poorly drained; poor workability.	Poor: high shrink-swell potential; poorly drained.	Unsuitable	Poor: silty clay; poorly drained; soluble salts.
*Serden: SmB For Maddock part, see Maddock series.	Poor: sand	Good	Fair for sand: fines.	Poor: loamy sand; less than 8 inches of suitable material.

properties of the soils—Continued

Soil features affecting—					
Pond reservoir areas	Embankments, dikes, and levees	Drainage for crops and pasture	Irrigation	Terraces and diversions	Grassed waterways
Moderately slow permeability; 0 to 6 percent slopes.	Medium to low shear strength; medium compressibility; fair to good compaction characteristics.	Not needed	Moderately slow permeability; high available water capacity; 0 to 6 percent slopes.	0 to 6 percent slopes; other soil features favorable.	All features favorable.
Slow permeability in substratum; 0 to 1 percent slopes.	Medium to low shear strength; medium and high compressibility; fair to poor compaction characteristics in substratum.	Not needed	Slow permeability in substratum; high available water capacity; 0 to 1 percent slopes.	0 to 1 percent slopes; clay substratum; slow permeability in substratum.	All features favorable.
Moderately slow permeability; seasonal water table; 0 to 1 percent slopes.	Medium to low shear strength; medium compressibility; poor to good compaction characteristics.	Moderately slow permeability; seasonal water table; subject to ponding; 0 to 1 percent slopes; availability of outlets.	Moderately slow permeability; high available water capacity; needs drainage.	0 to 1 percent slopes; moderately slow permeability.	Not needed.
Moderately slow permeability; seasonal water table; 0 to 1 percent slopes.	Medium to low shear strength; medium compressibility; fair to good compaction characteristics.	Moderately slow permeability; seasonal water table; subject to flooding; moderate salinity; 0 to 1 percent slopes.	Moderate available water capacity; seasonal water table; subject to flooding; moderate salinity; needs drainage.	Not needed	Not needed.
Very rapid permeability in coarse sand and gravel substratum; 1 to 3 percent slopes.	Medium to high shear strength; low to medium compressibility; fair to good compaction characteristics.	Not needed	Low available water capacity; very rapid permeability in substratum; 1 to 3 percent slopes.	1 to 3 percent slopes; shallow to coarse sand and gravel; erodible; difficult to vegetate.	Shallow to coarse sand and gravel; low available water capacity; difficult to vegetate.
Moderate permeability in upper part; moderately slow permeability in substratum; seasonal water table; 0 to 1 percent slopes.	Medium to low shear strength; low to medium compressibility; fair to good compaction characteristics.	Seasonal water table; moderately slow permeability in underlying material; 0 to 1 percent slope.	0 to 1 percent slopes; needs drainage; seasonal water table; moderately slow permeability in substratum.	Not needed	Poorly drained; high available water capacity; few stones.
Very slow permeability; seasonal water table; 0 to 1 percent slopes.	Medium to low shear strength; high compressibility; fair to poor compaction characteristics.	Very slow permeability; seasonal water table; claypan subsoil; 0 to 1 percent slopes; subject to ponding in some places.	Very slow permeability; salts in substratum; claypan subsoil.	Dense clay subsoil; very slow permeability; difficult to vegetate; poor workability.	Not needed.
Rapid permeability; 1 to 6 percent slopes.	Medium shear strength; low to medium compressibility; medium to high susceptibility to piping; fair to good compaction characteristics; high to medium permeability of compacted soil.	Not needed	Low available water capacity; rapid permeability; 1 to 6 percent slopes; very severely susceptible to soil blowing.	Highly susceptible to soil blowing; 1 to 6 percent slopes.	Not needed.

TABLE 8.—*Interpretations of engineering*

Soil series and map symbols	Suitability as a source of—			
	Cover material for sanitary landfill	Roadfill	Sand and gravel	Topsoil
*Sioux: SrB For Arilla part, see Arilla series.	Poor: shallow to gravel.	Good	Good for gravel and sand.	Poor: shallow to gravel; less than 8 inches of suitable material.
Swenoda: Sv, Sw	Good	Fair: moderate frost action potential.	Unsuitable	Good
Tiffany: Tf	Poor: poorly drained.	Poor: poorly drained.	Poor for sand: fines. Unsuitable for gravel.	Poor: poorly drained.
Tonka: To	Poor: poorly drained.	Poor: poorly drained.	Unsuitable	Poor: poorly drained.
Towner: TrA	Good: sandy loam and loam. Fair: loamy sand	Fair: shrink-swell potential; frost action potential.	Unsuitable	Good
Ulen: Un	Fair: loamy sand	Fair: moderate frost action potential.	Fair for sand: fines.	Fair: less than 16 inches of suitable material.
*Vallers: Vd For Doran part, see Doran series.	Poor: poorly drained.	Poor: high frost action potential.	Unsuitable	Fair: clay loam
Viking: Vk	Poor: poorly drained; poor workability.	Poor: high shrink-swell potential; poorly drained.	Unsuitable	Poor: clay; poorly drained.
Wahpeton: WaA	Poor: poor workability.	Poor: high shrink-swell potential.	Unsuitable	Poor: silty clay

properties of the soils—Continued

Soil features affecting—					
Pond reservoir areas	Embankments, dikes, and levees	Drainage for crops and pasture	Irrigation	Terraces and diversions	Grassed waterways
Very rapid permeability in coarse sand and gravel substratum; 1 to 6 percent slopes.	High to medium shear strength; low to medium compressibility; fair to good compaction characteristics.	Not needed	Very low available water capacity; very rapid permeability in coarse sand and gravel substratum.	Shallow to coarse sand and gravel; 1 to 6 percent slopes; difficult to vegetate; erodible.	Not needed.
Moderately rapid permeability in upper part; moderately slow permeability in lower part; 0 to 1 percent slopes.	Medium to low shear strength; medium to low compressibility; fair to good compaction characteristics.	Not needed	Moderately slow permeability in substratum; moderate available water capacity; 0 to 1 percent slopes.	0 to 1 percent slopes; severely susceptible to soil blowing.	Not needed.
Moderate and moderately rapid permeability; seasonal water table; 0 to 1 percent slopes.	Medium to low shear strength; medium to low compressibility; poor to good compaction characteristics.	Poorly drained; seasonal water table; subject to ponding; 0 to 1 percent slopes.	Moderate available water capacity; moderate and moderately rapid permeability; seasonal water table; needs drainage.	0 to 1 percent slopes; susceptible to soil blowing.	Not needed.
Slow permeability; seasonal water table; 0 to 1 percent slopes.	Medium to low shear strength; medium to high compressibility; low permeability of compacted soil.	Slow permeability; subject to ponding; outlets not available in some places; 0 to 1 percent slopes.	Slow permeability; needs drainage; 0 to 1 percent slopes.	Not needed	Not needed.
Rapid permeability in upper part; moderately slow permeability in substratum; seasonal water table; 1 to 3 percent slopes.	Medium to low shear strength; fair to good compaction characteristics; medium to high susceptibility to piping in upper part.	Not needed	Rapid intake rate; moderately slow permeability in substratum; moderate available water capacity; severely susceptible to soil blowing.	1 to 3 percent slopes; susceptible to soil blowing; erodible in upper part.	Erodible in upper part; 1 to 3 percent slope.
Rapid permeability; seasonal water table; 0 to 1 percent slopes.	Medium shear strength; low to medium compressibility; medium to high susceptibility to piping; fair to good compaction characteristics.	0 to 1 percent slopes; seasonal water table; rapid permeability.	Rapid permeability; seasonal water table; low available water capacity; severely susceptible to soil blowing.	0 to 1 percent slopes; high susceptibility to soil blowing.	Highly susceptible to soil blowing; high potential for windblown accumulations.
Moderately slow permeability; seasonal water table; 0 to 1 percent slopes.	Medium to low shear strength; medium compressibility; fair to good compaction characteristics.	Moderately slow permeability; seasonal water table; 0 to 1 percent slopes; availability of outlets.	Moderately slow intake rate; needs drainage; seasonal water table.	0 to 1 percent slopes; few stones; moderately slow permeability.	Not needed.
Very slow permeability; seasonal water table; 0 to 1 percent slopes.	Medium to low shear strength; high compressibility; fair to poor compaction characteristics.	Very slow permeability; seasonal water table; clay; 0 to 1 percent slopes.	Very slow permeability; seasonal water table.	0 to 1 percent slopes; few stones; very slow permeability.	Not needed.
Moderate permeability; 1 to 3 percent slopes.	Medium to low shear strength; high compressibility; fair to poor compaction characteristics.	Not needed	Moderate permeability; subject to stream overflow; 1 to 3 percent slopes.	1 to 3 percent slopes; moderate permeability.	Not needed.

TABLE 8.—*Interpretations of engineering*

Soil series and map symbols	Suitability as a source of—			
	Cover material for sanitary landfill	Roadfill	Sand and gravel	Topsoil
Wheatville: Wn	Fair: thickness of silt loam material.	Poor: high frost action potential; high shrink-swell potential in substratum.	Unsuitable	Fair: less than 16 inches of suitable material.
*Wyndmere: Wn, Wo, Wt. For Tiffany part of Wt, see Tiffany series.	Good	Poor: high frost action potential.	Poor for sand: fines. Unsuitable for gravel.	Fair: less than 16 inches of suitable material.
Ws	Fair: moderate salinity.	Poor: high frost action potential.	Fair for sand: fines.	Fair: moderate salinity; less than 16 inches of suitable material.
Zell: ZeE	Slight: 6 to 9 percent slopes. Moderate: 9 to 15 percent slopes. Severe: 15 to 25 percent slopes.	Fair: moderate frost action potential; 15 to 25 percent slopes.	Unsuitable	Poor: less than 8 inches of suitable material; 15 to 25 percent slopes.

[1] Pollution is a hazard in places because of permeability in substratum.

melt-water deposits, but with increasing distances eastward, thinner melt-water deposits. In soil associations 6, 7, 8, and 9, most of the soils formed in glacial melt-water deposits.

The glacial till deposits are mainly in the north-central and southwestern parts of the county. These deposits, carried by glaciers and deposited in contact with glaciers, are a mixture of sand, gravel, and stones in a matrix of silt and clay. In Traill County they have been reworked by the water of Glacial Lake Agassiz. In soil associations 11 and 12, most of the soils formed in glacial till that has been water-worked. Some of these soils have a thin to moderately thick layer of glacial melt-water deposits underlain by glacial till. Most of the soils in soil association 10 have a moderately thick or thick layer of water-worked glacial till underlain by glacial melt-water deposits. Some of these soils have thin to moderately thick layers of glacial melt-water deposits underlain by glacial till. In soil association 14, most of the soils formed in water-worked glacial till.

Post-glacial alluvium is on bottom lands of rivers and streams throughout the county, where they were recently deposited. They range from sand to clay and are commonly stratified. The most extensive area of post-glacial alluvium in Traill County is on bottom lands of the Goose River. On bottom lands in association 13, the soils formed in recent alluvium. On breaks in this association, they formed mainly in glacial lacustrine deposits and glacial melt-water deposits.

The sand and gravel deposits are mainly on beaches throughout the county. In one area near Cummings, a feature interpreted as an ice contact ridge contains considerable gravel. The beaches were formed by wave action on the receding shoreline of Glacial Lake Agassiz. They are oriented in a north-south direction. The layers of coarse sand and gravel are thin, generally about 3 to 6 feet thick. They are underlain by fine sand or finer textured material. In soil association 5 some of the soils formed in coarse sand and gravel, and others formed in glacial melt-water deposits and glacial till.

Differences among the soils are caused partly by differences in the kinds of parent material in which the soils formed. For example, soils, such as the Maddock soils, that formed in sandy material have a low available water capacity, rapid permeability, and low natural fertility. Soils, such as the Gardena soils, that formed in loamy material generally have a good sup-

properties of the soils—Continued

Soil features affecting—					
Pond reservoir areas	Embankments, dikes, and levees	Drainage for crops and pasture	Irrigation	Terraces and diversions	Grassed waterways
Moderately rapid permeability in upper part; slow permeability in substratum; seasonal water table; 0 to 1 percent slopes.	Medium to low shear strength; medium to high compressibility; fair to poor compaction characteristics; high susceptibility to piping in upper part.	Slow permeability in substratum; seasonal water table; 0 to 1 percent slopes.	Slow permeability in substratum; 0 to 1 percent slopes; seasonal water table.	0 to 1 percent slopes; poor workability in substratum; erodible in upper part.	0 to 1 percent slopes; erodible in upper part; high available water capacity.
Moderately rapid permeability; seasonal water table; 0 to 1 percent slopes.	Medium shear strength; low to medium compressibility; fair to good compaction characteristics; susceptible to piping.	Moderately rapid permeability; seasonal water table; 0 to 1 percent slopes.	Moderate available water capacity; moderately rapid permeability; seasonal water table.	0 to 1 percent slopes; susceptible to soil blowing.	0 to 1 percent slopes; susceptible to soil blowing.
Moderately rapid permeability; seasonal water table; 0 to 1 percent slopes.	Medium shear strength; low to medium compressibility; fair to good compaction characteristics.	Moderately rapid permeability; seasonal water table; moderate salinity; 0 to 1 percent slopes.	Moderate salinity; moderate available water capacity; moderately rapid permeability; seasonal water table.	Susceptible to soil blowing; difficult to vegetate; 0 to 1 percent slopes.	0 to 1 percent slopes; difficult to vegetate; susceptible to soil blowing.
Moderate permeability; 6 to 25 percent slopes.	Medium to low shear strength; medium compressibility; high susceptibility to piping; fair to good compaction characteristics.	Not needed	Moderate permeability; high available water capacity; 6 to 25 percent slopes; very severe hazard of water erosion on steeper slopes.	6 to 25 percent slopes; highly erodible.	6 to 25 percent slopes; highly erodible.

ply of plant nutrients and a good available water capacity. Soils, such as the Fargo soils, that formed in clayey material have slow permeability and poor drainage.

Climate

Traill County has a cool, subhumid, continental climate characterized by long, cold winters and warm, relatively moist summers. The climate is uniform throughout the county. The average annual precipitation is about 20 inches, of which more than 75 percent falls during the growing season, April to September. Maximum temperatures during the summer average 81° F, but temperatures of 90° are common. In winter the temperature averages 10°, and in most years snow covers the ground from the first of December until the middle of March. The soil is generally frozen to a depth of 4½ to 6½ feet from November to April. In this climate, tall grasses are the dominant vegetation.

The climate has had a direct effect on soil formation in the county. Temperature and moisture have influenced the accumulation of organic matter in the surface layer, the weathering of parent material, and the leaching and accumulation of carbonates and soluble salts.

Temperature affects the rate of chemical reactions and the activity of living organisms. Cool temperatures slow the decay of plant and animal matter and thus promote the accumulation of organic matter in the soils. Most of the soils in the county have a thick, black surface layer, which indicates a large amount of organic matter. Freezing and thawing and wetting and drying help to weather parent material and also help to maintain good soil structure by breaking down large clods and mixing the soil material by frost heaving. These results are especially significant in clayey soils.

Moisture is needed for chemical reactions to take place in the soil, for the growth of plants and animals, and for the removal, in solution, of the end products of decomposition. The moisture received in Traill County, particularly in the form of rainfall, has leached the carbonates from most of the moderately well drained and well drained soils to a depth of 15 to 30 inches or more. It has also been sufficient to leach soluble salts to a greater depth in most areas. In many

areas where the soils have a seasonal water table and where lateral movement of water takes place, a layer of accumulated lime is within 16 inches of the surface. In a few areas the quantity of soluble salts is sufficient to affect plant growth. Moisture has also been needed for the downward movement of clay in some soils.

Plant and animal life

The kind of vegetation in Traill County is dependent mainly on the climate and relief. Grasses are the dominant vegetation, and tall grasses are more abundant than other grasses. Native stands of trees and shrubs are mainly on the bottom lands of the Goose, Red, and Elm Rivers.

On the poorly drained, somewhat poorly drained, and moderately well drained, nearly level soils, such as those of the Fargo, Hegne, Bearden, Glyndon, Gardena, and Overly series, the native vegetation is mainly tall grasses. The principal grasses are big bluestem, switchgrass, indiangrass, and prairie sandreed.

On the well drained, nearly level to strongly sloping soils of the Great Bend, Eckman, Egeland, and Maddock series, tall and mid grasses are dominant. Among these grasses are switchgrass, big bluestem, sand bluestem, green needlegrass, western wheatgrass, and side-oats grama.

On the well drained and excessively drained, nearly level to moderately steep soils of the Serden, Sioux, Esmond, and Zell series, mid and short grasses are dominant. Among these grasses are green needlegrass, western wheatgrass, little bluestem, side-oats grama, and blue grama.

On the poorly drained and very poorly drained, depressional soils of the Arveson, Borup, Colvin, Grano, Tonka, and Dovray series, the vegetation consists of tall grasses, reeds, rivergrass, slough sedge, American mannagrass, northern reedgrass, and prairie cordgrass.

The activities of certain microorganisms, such as bacteria and fungi, are important in soil formation in Traill County. These micro-organisms break down undecomposed organic matter and change it to humus. Some bacteria take nitrogen from the air and change it into a form that can be used by plants. The activities of certain burrowing rodents, worms, and insects aid in the percolation of rainwater through the soil and cause some mixing of organic and inorganic materials.

The main effect of plant and animal life on soil formation is the accumulation of organic matter and the translocation of plant nutrients from the lower to the upper layers. Native grass has contributed large amounts of organic matter to the soils. The roots grow into the lower horizons, take up calcium, phosphorous, potassium, and other nutrients, then leave these elements near the surface when the plants die and decay. The soils that form in areas where there is calcium and a high content of organic matter in the surface layer have granular structure.

The activities of man, particularly in altering drainage, maintaining fertility, and changing the kinds of vegetation, have an important effect upon both the rate and direction of soil formation.

Relief

Most of Traill County is nearly level and has differences in relief of less than 1 to 10 feet in a square mile. A few areas on the glacial upland, on beaches, and on the breaks to drainageways and streams are gently sloping to moderately steep. In these areas the difference in relief is 10 to 60 feet in a square mile.

The Red, Goose, and Elm Rivers and Buffalo Coulee are the main rivers and streams in the county. A system of natural drains, field drains, road ditches, and floodways carries the excess water to these watercourses.

Relief affects the content of water in the soil, the temperature of the soil, and the degree of water erosion. It also influences the kind and amount of vegetation. Elevation, exposure, and slope are the components of relief that affect the formation of soils. In Traill County, the soils show little or no effect from elevation or exposure. The differences in elevation are so slight, only about 300 feet, that they do not have any noticeable effect on temperature, precipitation, and evaporation. Exposure, or the direction in which the slope faces, has produced no significant changes.

The one component of relief that has influenced the formation of soils in this county is slope. The degree of slope influences the amount and velocity of runoff and the degree of water erosion. The shape of the slope, whether convex, concave, or plane, determines whether precipitation runs off, flows across, or accumulates in the low or less sloping areas. Many differences in the soils in Traill County result from their slope characteristics.

In areas where runoff is rapid because the soils are on strongly sloping to moderately steep, convex side slopes and only a small percentage of the rainfall penetrates the soil, there is little moisture for the growth of plants and the formation of soil. As a result, the soils have a thin surface layer that is low in organic-matter content and has weak horizonation. Examples of soils in these areas are the Nutley and Zell soils.

In areas where runoff is medium or slow and the soils are on convex side slopes and are nearly level to sloping and well drained, there is sufficient moisture to support good stands of mixed native grasses, and the soils have a well developed profile characterized by a dark colored A horizon and a dark grayish brown to brown B horizon. Examples of soils in these areas are the Great Bend, Egeland, Eckman, and Heimdal soils.

In areas where most of the soils are moderately well drained and nearly level to gently sloping and where slopes are plane or slightly concave, the A horizon is generally thicker, the B horizon is darker colored, and lime is at a greater depth than in areas where the soils are strongly sloping and on convex side slopes. Examples of soils in these areas are the Overly, Gardena, Embden, and Hecla soils.

In areas where soils are nearly level and level and on slightly convex and plane slopes, runoff is slow to very slow, there is a seasonal high water table, and drainage is somewhat poor and poor. These soils have a zone of lime accumulation within 16 inches of the surface if lime is held at or near the surface. Lime may be held or accumulated as a result of a seasonal water table, capillary action, or lateral movement of water. Use of water by plant roots may also affect the accumulation of lime. The layer where lime accumulates is commonly dark gray to light brownish gray. Examples of soils in

these areas are the Bearden, Glyndon, Borup, Colvin, Wyndmere, and Hegne soils.

In concave depressional areas that receive runoff from higher areas, the soils have poor and very poor natural drainage and, mainly, are characterized by a thick, black A horizon and a mottled gray or olive subsoil and substratum. Examples of soils in these areas are the Dovray, Tonka, and Perella soils.

Time

Time is necessary for the factors of soil formation to act on parent material. The length of time for a particular soil to develop depends on the kind of parent material and many other factors.

The soils of Traill County range from mature soils that have well-developed characteristics to young soils that have very little or no horizon differentiation, or profile development. The well drained soils, such as those of the Great Bend series, are among the most mature soils in the county. The somewhat poorly drained soils, such as those of the Cashel series, which are on the bottom lands of streams and rivers, are the youngest soils in the county.

Most differences in profile development result from the combined effect of other soil-forming factors rather than the effect of time.

Classification of the Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationship to one another and to the whole environment, and to develop principles that help us to understand their behavior and their response to management. First through classification, and then through the use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

The narrow categories of classification, such as those used in detailed soil surveys, allow us to organize and apply knowledge about soils in managing farms, fields, and woodlands; in developing rural areas; in engineering work; and in many other ways. Soils are placed in broad classes to facilitate study and comparison in large areas, such as countries and continents.

The current system of soil classification was adopted by the National Cooperative Soil Survey in 1965. Because this system is under continual study, readers interested in developments of the current system should search the latest literature available, (*7*, *9*).

The current system of classification has six categories. Beginning with the broadest, these categories are order, suborder, great group, subgroup, family, and series. In this system the criteria used as a basis for classification are soil properties that are observable and measurable. The properties are selected so that the soils of similar genesis, or mode of origin, are grouped together. The same property, or subdivisions of this property, may be used in several different categories. In table 9, the soil series of Traill County are placed in three categories of the current system. Classes of the current system are briefly defined in the following paragraphs.

ORDERS.—Ten soil orders are recognized. The properties used to differentiate among soil orders are those that tend to give broad climatic groupings of soils. Three exceptions are the Entisols, Histosols, and Vertisols, which occur in many different climates. Each order is named with a word of three or four syllables ending in *sol* (Moll-i-sol).

SUBORDER.—Each order is divided into suborders using those soil characteristics that seem to produce classes with the greatest genetic similarity. The suborders are more narrowly defined than are the orders. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of a water table at a shallow depth; soil climate; the accumulation of clay, iron, or organic carbon in the upper part of the solum; cracking of soils caused by a decrease in soil moisture; and fine stratification. The names of suborders have two syllables. The last syllable indicates the order. An example is *Aquoll* (*Aqu*, meaning water or wet, and *oll*, from Mollisol).

GREAT GROUP.—Suborders are separated into great groups on the basis of uniformity in the kinds and sequence of soil horizons and features. The horizons considered are those in which clay, carbonates, and other constituents have accumulated or have been removed and those that have pans that interfere with the growth of roots or the movement of water, or both. Some soil features used are acidity, temperature, composition, and color. The names of great groups have three or four syllables and are made by adding a prefix to the name of the suborder. An example is Haplaquoll (*Hapl*, meaning simple horizons, *aqu* for wetness or water, and *oll*, from Mollisol).

SUBGROUP.—Great groups are divided into subgroups, one representing the central (typic) segment of the group, and others, called intergrades, that have properties of the group and also one or more properties of another great group, subgroup, or order. Other subgroups may have soil properties unlike those of any other great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the name of the great group. An example is Typic Haplaquolls (a typical Haplaquoll).

FAMILY.—Families are separated within a subgroup primarily on the basis of properties important to the growth of plants or to the behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, soil depth, and consistence. A family name consists of a series of adjectives preceding the subgroup name. The adjectives are the class names for texture, mineralogy, and so on, that are used to differentiate families. An example is the coarse-loamy, mixed, frigid family of Typic Haplaquolls.

SERIES.—The series is a group of soils that have major horizons that, except for texture of the surface layer, are similar in important characteristics and in arrangement in the profile.

Environmental Factors Affecting Soil Use

Traill County was one of the earliest areas settled in what is now North Dakota. The towns of Caledonia and Belmont were founded as early as 1870. Most of

TABLE 9.—*Classification of soil series*

Series	Family	Subgroup	Order
Arveson	Coarse-loamy, frigid	Typic Calciaquolls	Mollisols.
Arvilla	Sandy, mixed	Udic Haploborolls	Mollisols.
Bearden	Fine-silty, frigid	Aeric Calciaquolls	Mollisols.
Beotia	Fine-silty, mixed	Pachic Udic Haploborolls	Mollisols.
Bohnsack	Coarse-silty, frigid	Aeric Calciaquolls	Mollisols.
Borup	Coarse-silty, frigid	Typic Calciaquolls	Mollisols.
Cashel	Fine, montmorillonitic, frigid	Mollic Udifluvents	Entisols.
Colvin	Fine-silty, frigid	Typic Calciaquolls	Mollisols.
Divide	Fine-loamy over sandy or sandy-skeletal, frigid	Aeric Calciaquolls	Mollisols.
Doran	Fine, mixed	Aquic Argiborolls	Mollisols.
Dovray	Fine, montmorillonitic, frigid	Cumulic Haplaquolls	Mollisols.
Eckman	Coarse-silty, mixed	Udic Haploborolls	Mollisols.
Egeland	Coarse-loamy, mixed	Udic Haploborolls	Mollisols.
Embden	Coarse-loamy, mixed	Pachic Udic Haploborolls	Mollisols.
Emrick [1]	Coarse-loamy, mixed	Pachic Udic Haploborolls	Mollisols.
Enloe	Fine, montmorillonitic, frigid	Argiaquic Argialbolls	Mollisols.
Esmond	Coarse-loamy, mixed	Udorthentic Haploborolls	Mollisols.
Fairdale	Fine-loamy, mixed, frigid	Mollic Udifluvents	Entisols.
Fargo	Fine, montmorillonitic, frigid	Vertic Haplaquolls	Mollisols.
Galchutt	Fine, montmorillonitic, frigid	Typic Argialbolls	Mollisols.
Gardena	Coarse-silty, mixed	Pachic Udic Haploborolls	Mollisols.
Gilby	Fine-loamy, frigid	Typic Calciaquolls	Mollisols.
Glyndon	Coarse-silty, frigid	Aeric Calciaquolls	Mollisols.
Grano	Fine, montmorillonitic (calcareous), frigid	Vertic Haplaquolls	Mollisols.
Great Bend	Fine-silty, mixed	Udic Haploborolls	Mollisols.
Hamar	Sandy, mixed, frigid	Typic Haplaquolls	Mollisols.
Hamerly	Fine-loamy, frigid	Aeric Calciaquolls	Mollisols.
Hecla	Sandy, mixed	Udic Haploborolls	Mollisols.
Hegne	Fine, frigid	Typic Calciaquolls	Mollisols.
Heimdal	Coarse-loamy, mixed	Udic Haploborolls	Mollisols.
LaDelle	Fine-silty, mixed	Cumulic Udic Haploborolls	Mollisols.
Lamoure	Fine-silty, mixed (calcareous), frigid	Cumulic Haplaquolls	Mollisols.
Lankin	Fine-loamy, mixed	Pachic Udic Haploborolls	Mollisols.
La Prairie	Fine-loamy, mixed	Cumulic Udic Haploborolls	Mollisols.
Lindaas	Fine, montmorillonitic, frigid	Typic Argiaquolls	Mollisols.
Ludden	Fine, montmorillonitic (calcareous), frigid	Vertic Haplaquolls	Mollisols.
Maddock	Sandy, mixed	Udorthentic Haploborolls	Mollisols.
Nahon	Fine, montmorillonitic	Udic Natriborolls	Mollisols.
Nutley [1]	Fine, montmorillonitic	Udertic Haploborolls	Mollisols.
Ojata	Fine-silty, frigid	Typic Calciaquolls	Mollisols.
Overly	Fine-silty, mixed	Pachic Udic Haploborolls	Mollisols.
Perella	Fine-silty, mixed, frigid	Typic Haplaquolls	Mollisols.
Playmoor	Fine-silty, mixed (calcareous), frigid	Cumulic Haplaquolls	Mollisols.
Renshaw	Fine-loamy over sandy or sandy-skeletal, mixed	Udic Haploborolls	Mollisols.
Rockwell	Coarse-loamy, frigid	Typic Calciaquolls	Mollisols.
Ryan	Fine, montmorillonitic, frigid	Typic Natraquolls	Mollisols.
Serden	Mixed, frigid	Typic Udipsamments	Entisols.
Sioux	Sandy-skeletal, mixed	Udorthentic Haploborolls	Mollisols.
Swenoda	Coarse-loamy, mixed	Pachic Udic Haploborolls	Mollisols.
Tiffany	Coarse-loamy, mixed, frigid	Typic Haplaquolls	Mollisols.
Tonka	Fine, montmorillonitic, frigid	Argiaquic Argialbolls	Mollisols.
Towner	Sandy over loamy, mixed	Pachic Udic Haploborolls	Mollisols.
Ulen	Sandy, frigid	Aeric Calciaquolls	Mollisols.
Vallers	Fine-loamy, frigid	Typic Calciaquolls	Mollisols.
Viking	Very fine, montmorillonitic (calcareous), frigid	Typic Haplaquolls	Mollisols.
Wahpeton	Fine, montmorillonitic	Udertic Haploborolls	Mollisols.
Wheatville	Coarse-silty over clayey, frigid	Aeric Calciaquolls	Mollisols.
Wyndmere	Coarse-loamy, frigid	Aeric Calciaquolls	Mollisols.
Zell	Coarse-silty, mixed	Udorthentic Haploborolls	Mollisols.

[1] The following soils are taxadjuncts to the series for which they are named:
The Emrick soil in Eo because it contains more silt and less sand than is defined as the range for the Emrick series.
The Nutley soil in NuE because its surface layer is lighter colored than is defined as the range for the Nutley series.

the early settlements were along the Red River and its tributaries because shelter was afforded by the narrow bands of timber and the supply of water was permanent.

The county was organized in 1875 when Caledonia, near the Red River, became the county seat. In 1891, when the Red River no longer served as the main mode of transportation, Hillsboro became the county seat.

After the railroads were built, settlement was rapid. The population of the county increased from 4,123 in 1880 to 13,107 in 1900. After 1900 the population decreased to a low of 9,571 in 1970. This decrease shows the influence of mechanization on farming, which not only enabled farmers to farm more acreage but also

created a need for more acreage to make up an economic farm unit. Many of the people who have left the farm have taken employment in industries that support farming in nearby towns, and many have left the area for the cities.

At present, about 992 farms are in operation (*5*), of which full owners operate 319; part owners, 446; and tenants, 227. These farms range from less than 100 acres to more than 1,000 acres in size, but they average 548 acres. A total of 726, or 73 percent of farms, grow cash-grain crops; 69, or 7 percent, grow other field crops; 45, or 4.5 percent, are general farms; and the remaining 152, or about 15 percent, raise livestock or are miscellaneous farms.

In 1970, the principal field crops were wheat, 94,000 acres harvested; barley, 69,000 acres; oats, 46,000 acres; flax for seed and rye 53,500 acres; hay, 17,000 acres; potatoes, 7,230 acres; sugar beets, 9,850 acres; and corn and soybeans, 10,200 acres. There has been a slight increase in the acreage of potatoes and sugar beets in recent years. Besides the field crops, a small acreage of peas, sweetclover for seed, mustard, and millet were grown. In recent years there has also been a marked increase in the acreage of special crops, mainly sunflowers, 18,500 acres harvested in 1970, and edible beans.

When compared with the sale of crops, the sale of livestock is small, but it is an additional source of income for some farmers. The raising of livestock has always been a minor farm enterprise in Traill County because a large acreage is suited to crops. On farms in the county in 1971, there were 13,000 cattle, 5,500 hogs, 1,900 sheep, and 44,000 chickens.

Transportation is furnished by railroads, trucks, and a good road system that includes an interstate highway and state highways. The railroads and trucks transport large amounts of produce, especially wheat and barley, to distribution points and processing centers.

Interstate 29 crosses the county in a north-south direction and passes near the towns of Kelso, Hillsboro, Taft, Cummings, Buxton, and Reynolds. State Highway 200 crosses the county in an east-west direction and passes through the towns of Hillsboro, Taft, Mayville, and Portland. State Highway 18 crosses the county in a north-south direction and passes through the towns of Blanchard, Mayville, Portland, and Hatton. Hard-surfaced and graveled roads serve the remaining towns of Clifford, Galesburg, and Caledonia. Graveled and graded roads constructed along the section lines are also used to reach farms in the county.

The nearest commercial airline facilities are in adjacent Cass County to the south and in Grand Forks County to the north. Hillsboro and Mayville have airports for small light airplanes.

Climate[6]

The climate of Traill County is typically continental. Temperatures range widely on both an annual and a daily basis. Air mass systems that move rapidly through the area are common. Cold, dry air masses from the polar regions intensify the winters, but warm relatively moist air masses from the Gulf of Mexico largely determine the precipitation in the area. Rainfall in spring is generally light, increases until late in June, and then gradually declines through the winter. In this county, because of its geographic location, daylight ranges from less than 9 hours in December to more than 16 hours in June.

Table 10 gives temperature, precipitation, and cloudiness data for Traill County.

The air temperature is typical of a continental climate, and because of the northerly location of Traill County, it is extremely variable. Mean annual temperature ranges from 40 to 41° F, but this range tells very little about temperature climatology in the area. The average daily temperatures range from 5.0° in January to 70.5° in July. The average daily minimum in January is -4.7°, and the average daily maximum in July is 83.8°. In 15 days of an average year in Traill County, the maximum daily temperature exceeds 90°. During the hottest days, from the last week in July through mid-August, there is at least 65 to 75 percent chance that the maximum temperature will exceed 90° on one day of the week. Such temperatures negatively affect crop yields in North Dakota.

In only 130 days of an average year are minimum daily temperatures continuously above freezing. On an average, the first freeze in fall is expected about September 23, and the last freeze in spring is about May 15. The length of the frost-free period, which is about the length of the growing season, is based on temperature readings of instruments in shelters exposed 5 feet above the ground. Generally air temperatures closer to the ground are 3° to 7° lower than those measured inside the shelter, particularly on clear, calm nights and early in the mornings when radiation loss from the ground and overlying air layers is not impeded by clouds.

In Traill County small grains are commonly planted when average air temperatures are about 40°. The probabilities of weekly temperatures of 40° or more are: 10 to 20 percent from March 22 to 28; 20 to 25 percent from March 29 to April 4; 30 to 35 percent from April 5 to 11; 60 to 65 percent from April 12 to 18; 80 to 85 percent from April 19 to 25; and 85 to 90 percent from April 26 to May 2.

In planning farm and other outdoor activities, freezing temperatures can directly influence the scheduling of work. The probabilities of temperatures of 32° or below in spring are: 75 to 80 percent from May 3 to 9; 35 to 40 percent from May 17 to 23; and 10 to 15 percent from May 31 to June 6. In fall the probabilities are: 5 to 10 percent from August 30 to September 5; 25 to 30 percent from September 13 to 19; and 70 to 75 percent from September 27 to October 3.

The probabilities of below zero temperatures for 5 consecutive days in winter are as follows: 30 to 35 percent from December 13 to 19; 35 to 40 percent from December 27 to January 2; 50 to 55 percent from January 10 to 16; 55 to 60 percent from January 24 to 30; 35 to 40 percent from February 7 to 13; and 25 to 30 percent from February 21 to 29. If high winds accompany these temperatures, the livestock need special protection, and outdoor activity is greatly curtailed or made much more difficult.

[6] By J. M. RAMIREZ, associate professor of soils (climatology), North Dakota State University.

TABLE 10.—*Temperature, precipitation, and cloudiness data*

Month	Temperature			Precipitation		Average number of days, sunrise to sunset, that are—		
	Average daily maximum	Average daily minimum	Average daily	Average total	Average snowfall	Clear	Partly cloudy	Cloudy
	°F	°F	°F	*Inches*	*Inches*			
January	14.6	−4.7	5.0	0.54	5.3	6	8	17
February	21.3	.9	11.1	.44	4.2	7	7	14
March	34.2	14.2	24.6	.72	4.4	5	9	17
April	53.1	30.6	41.8	1.58	2.4	6	9	15
May	68.4	41.7	55.1	2.49	.2	7	10	14
June	77.0	52.1	64.7	3.75	0	6	11	13
July	83.6	57.4	70.5	2.85	0	11	13	7
August	82.5	55.2	68.8	2.32	0	11	12	8
September	71.6	45.5	58.4	1.94	.1	9	9	12
October	59.8	34.5	46.8	1.16	.5	10	8	13
November	37.6	19.5	28.5	.70	3.6	5	7	18
December	21.3	4.0	13.0	.60	4.7	6	8	17
Year	52.1	29.2	40.7	19.09	25.4	89	111	165

Extended periods of above-freezing temperatures in winter are periods when outdoor work that involves construction or other engineering activities can be planned or completed and when the possible flooding that can result from the melting of snow as well as possible frost heave can be evaluated. The probabilities of a minimum temperature of 32° on 5 consecutive days in winter are as follows: more than 90 percent from October 25 to 31; 60 to 65 percent from November 8 to 14; 10 to 15 percent from December 6 to 12; less than 10 percent from January 3 to 9 and January 31 to February 6; 15 to 20 percent from March 1 to 7; and 85 to 90 percent from March 29 to April 4.

In an average year, Traill County receives about 19 to 20 inches of precipitation, mostly in the form of rain. Despite this small amount, which places the county in a subhumid climate, this precipitation is beneficial to area industry and to small grain farming because more than 75 percent falls in the period April through September. At the Mayville Station in this county, more than 20 inches of annual precipitation has been recorded for 24 of the last 70 years. In 1923, the annual precipitation was as little as 6 inches.

Weekly precipitation gradually increases at the beginning of spring from about a tenth of an inch a week to almost an inch a week in the third week of June. It then gradually decreases to less than one-tenth of an inch in the later part of September. The chance of receiving as much as one-half inch of rain per week in March, April, and May is 20 to 50 percent.

About one-fourth of the annual precipitation in Traill County falls as snow. On about 40 days in winter at least 6 inches of snow can be expected to remain on the ground. On the average, the first inch of accumulation can be expected in the first week of December and the last inch as late as the last week in March.

In spring, which is cool, the amount of precipitation received compares closely with the amount lost through evaporation. During the hot summer when moisture deficits are definitely more critical, about one-fourth inch of water a day can be lost from an open evaporating surface, but loss by transpiration of crops is generally less.

Prevailing wind directions recorded at three nearby National Weather Service Stations show that northwesterly winds prevail from November through early in spring, but variable southerly winds prevail from May through summer and fall. Average windspeeds are 8 to 13 miles an hour.

Most of the summer precipitation in Traill County is associated with severe storm activity. About 35 thunderstorm days occur each year. The peak activity is in July when thunderstorms occur on an average of 8 days. Tornadoes also occur in Traill County, and about 40 reports of hail damage have been made during a 20-year period. Hail occurs mainly in June, July, and August.

The relative humidity and the dew-point temperature reflect the moisture content in the air. Relative humidity is highest in mid winter and ranges from 68 to 80 percent throughout the day. A much lower humidity occurs in afternoons in summer and late in fall, and consequently these seasons are more pleasant. Dewpoint temperatures range from just above 0° F in winter to 50° in summer and follow closely air temperature trends.

According to a study by Ramirez and Cassel [7], 16 droughts and 17 wet periods occurred in the county in the period 1930 through 1970. This study also indicated that in more than half the years the weather caused some restriction on the growth of crops during the growing season. The long severe droughts in the 1930's and the wet periods in the 1940's were followed by alternating periods when there were moderate moisture surpluses and when there were moisture deficits. Wet periods late in the 1960's were markedly wetter than those in earlier years.

[7] Information obtained from an unpublished manuscript, Drought and Wet Spells in North Dakota, by J. M. Ramirez and D. K. Lassel.

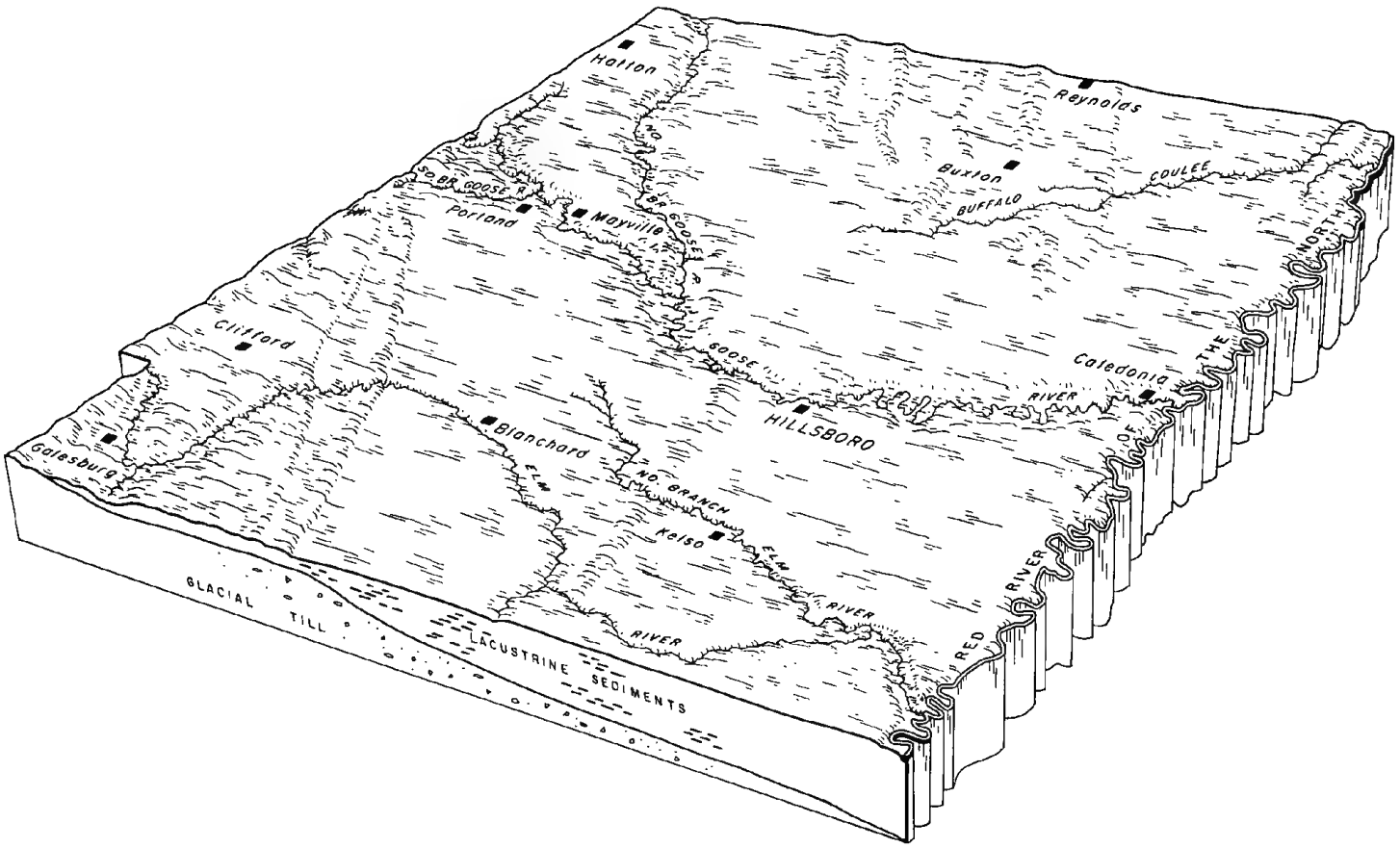

Figure 18.—Relief map of Traill County, North Dakota.

Physiography, Relief, and Drainage

Traill County is in the western lake section of the Central Lowland physiographic province. All of the county is within the Lake Agassiz Plain, except for a small area that is within the Drift Prairie. The Lake Agassiz Plain can be divided in the lake plain, deltas, interbeach areas, and bottom lands. Beaches are common on the deltas and in interbeach areas, but they occur less commonly on the lake plain. The elevation on the lake plain ranges from about 1,000 feet in the western part of the county to 850 feet in the northeastern corner.

The lake plain is flat and has local relief that is generally less than 2 feet (*3*). It slopes downward across the county toward the northeast at an average of about 8 feet per mile (fig. 18).

The deltas, which are in the western part of the county, are flat and have local relief that ranges from about 5 feet in the northwestern part to about 15 feet in the southwestern part. The delta in the northwestern part slopes downward toward the southeast at about 12 feet a mile, but the delta in the southwestern part slopes downward toward the east at about 20 to 30 feet a mile.

The interbeach areas are flat and have local relief that is about 5 feet. Within the interbeach areas that cross the county in a north-south direction are beaches that have local relief ranging from 5 to 20 feet. In the north-central part of the county, the interbeach area slopes downward toward the east at about 10 feet a mile, but in the southwestern part, at about 20 to 25 feet a mile. The interbeach area has more gradient per mile and greater local relief in the southwestern part of the county than in the north-central part.

The bottom lands are generally nearly level, and on the flood plains and terraces, local relief is less than 15 feet. Relief is greatest in meandering, abandoned stream channels, in present stream channels, and on breaks leading from the higher terraces to the flood plains.

The extreme southwestern part of the county, which is the small area within the Drift Prairie, is nearly level to rolling and has local relief of 20 to 40 feet.

The lake plain generally has poorly developed drainage. There are a few large sloughs, but many, shallow, small depressions and swales mainly in the eastern part. Excess water is removed by a system of field drains, road ditches, floodways, coulees, and natural streams.

The deltas generally have poorly developed drainage. They have a few large sloughs mainly in the southwestern part of the county, but small, shallow depressions and swales are common. Excess water is removed by a system of field drains, road ditches, coulees, and natural streams.

In the north-central part of the county, the interbeach area has poorly developed natural drainage and

many, small, shallow depressions. In the southwestern part of the county, the interbeach area has common, small, shallow depressions and swales but is generally better drained than that in the north-central part because it has more gradient a mile and greater local relief. Excess water is removed by a system of field drains, road ditches, coulees, and natural streams.

The rivers along which the bottom lands occur are the Goose River, the Elm River, and the Red River, which marks the eastern boundary of the county, and Buffalo Coulee. The bottom lands along the Goose River, which is the major stream draining the central and northwestern parts of the county, generally have good drainage, except along the cutoff oxbows and the upper reaches of the North Branch. Those along the Elm River, which drains the southern part of the county, have good to poor drainage. The bottom lands along the Red River generally have good to somewhat poor drainage. All runoff eventually reaches the Red River by means of the natural streams, floodways, road ditches, and field drains. The channel of Buffalo Coulee, which drains the northeastern and north-central parts of the county, is difficult to trace across the interbeach area and the lake plain because it is not well defined in some places.

The extreme southwestern part of the county, which is part of the Drift Prairie, is drained mainly by natural drainageways and streams.

Native Vegetation

The native vegetation in Traill County was mainly prairie grasses, except for the trees and shrubs that grew on the flood plains of the Elm, Goose, and Red Rivers. At present, there are few, if any, areas in the county that are in native vegetation because they have never been plowed.

Of the prairie grasses in the county, the tall grasses were most abundant. At one time, before any plowing had been done, the greater part of Lake Agassiz Plain was covered with tall prairie grasses that grew to a height of 3 to 6 feet. Among the main grasses were big bluestem, switchgrass, indiangrass, and prairie sandreed.

Of the trees and shrubs that were native to the bottom lands along streams, most kinds are still growing in the county. Among the main trees and shrubs are ash, boxelder, bur oak, elm, and hackberry. Of the few areas that have been cleared, most are now used for crops.

Water Supply

The main source of water in Traill County is wells. The principal aquifers of the county are the Dakota, Hillsboro, Galesburg, Elk Valley, and Belmont aquifers (*4*).

The most important aquifer is the Dakota aquifer which is in the beds of sand and sandstone of the Dakota formation. It underlies nearly all of the county and is at a depth of about 250 to more than 400 feet. Of the wells that tap the Dakota aquifer, about 50 percent flow. The water from this aquifer is highly mineralized and generally not suited for domestic consumption, but it can be used for livestock. It contains a large amount of sodium sulfate and, in some places, a large amount of sodium chloride. The yields range from a few gallons of water a minute by natural flow to about 1,000 gallons in a minute or more by pumping.

The four remaining important aquifers are in glacial drift. The Hillsboro aquifer consists of a long narrow deposit of sand and gravel that is about 25 miles long and 1 to 2 miles wide. It extends northward from the southern boundary of the county, just west of Hillsboro, and slightly to the northwest. This aquifer appears to be associated with Hillsboro beach, but near Hillsboro it goes northwest and crosses beneath Blanchard and McCauleyville beaches. It is generally 50 to 100 feet thick. The water from this aquifer is very hard and generally contains large amounts of iron. The Hillsboro aquifer has potential for further development. Depending on the permeability of the water bearing material, this aquifer could yield as much as 500 gallons per minute.

The Galesburg aquifer is in the southwestern part of Traill County and covers an area of about 85 square miles. This aquifer is associated with the Galesburg Delta. It consists of very fine sand to fine sand and is generally less than 50 feet thick. The water is hard. The Galesburg aquifer appears to have limited development potential. It is estimated that wells at favorable locations could produce as much as 250 gallons of water a minute.

The Elk Valley aquifer is in the northwestern part of Traill County and covers an area of about 60 square miles. This aquifer is associated with the Elk Valley Delta. It consists of very fine sand and fine sand that is as much as 65 feet thick in places. The water is hard and contains large amounts of iron, locally. The Elk Valley aquifer appears to have little development potential. It is estimated that wells could yield up to 50 gallons in a minute or less in most places.

The Belmont aquifer underlies about 7 square miles in the northeastern part of the county. Since most of the aquifer is under Belmont Township, it has been named the Belmont aquifer. It consists of fine to coarse pebbles and sand. It generally is about 150 feet below the surface and is 160 feet thick at the most. The water is hard and generally unsuitable for irrigation. The Belmont aquifer appears to have limited development potential. It is estimated that wells could yield as much as 500 gallons in a minute in places.

There are numerous small aquifers in the till and beach deposits throughout the county. Generally these aquifers consist of sand and gravel that range from a few feet to as much as 50 feet in thickness. The water quality is variable, but the water from beach deposits is generally of better quality than the water from till deposits. The quantity of water available from these aquifers is small.

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Glossary

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates, such as crumbs, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alkali soil. Generally, a highly alkaline soil. Specifically, an alkali soil has so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that the growth of most crop plants is low from this cause.

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Available water capacity (also called available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.

Buffer strips. Narrow bands of tall annual crops or perennial plants grown to control erosion and to trap and spread snow over the field. Most buffers are used with fallow where stripcropping or windbreaks are not used.

Buried soil. A developed soil, once exposed but now overlain by more recently formed soil.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of clay on the surface of a soil aggregate. Synonyms: clay coat, clay skin.

Claypan. A compact, slowly permeable soil horizon that contains more clay than the horizon above and below it. A claypan is commonly hard when dry and plastic or stiff when wet.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds, or of soil grains cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Cover crop. A close-growing crop grown primarily to improve and to protect the soil between periods of regular crop production; or a crop grown between trees and vines in orchards and vineyards.

Drainage class (natural). Refers to the conditions of frequency and duration of periods of saturation or partial saturation that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural soil drainage are recognized.

Excessively drained soils are commonly very porous and rapidly permeable and have a low available water capacity.

Somewhat excessively drained soils are also very permeable and are free from mottling throughout their profile.

Well-drained soils are nearly free from mottling and are commonly of intermediate texture.

Moderately well drained soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons and mottling in the lower B and the C horizons.

Somewhat poorly drained soils are wet for significant periods but not all the time, and some soils commonly have mottling at a depth below 6 to 16 inches.

Poorly drained soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent or nearly so in some soils.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

Flood plain. Nearly level land, consisting of stream sediments, that borders a stream and is subject to flooding unless protected artificially.

Grassed waterway. A natural or constructed waterway, typically broad and shallow, and covered by grass for protection against erosion; used to conduct surface water away from cropland.

Gumbo spots. Small areas where the plow layer is soft and sticky when wet and very hard or extremely hard when dry because fine textured, saline material from the subsoil has been mixed into the plow layer.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.— The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Lacustrine deposit (geology). Material deposited in lake water and exposed by lowering of the water level or elevation of the land.

Leaching. The removal of soluble materials from soils or other material by percolating water.

Legal Drain. Constructed water courses that remove excess water from the soil from a given drainage area.

Made land. Areas filled artificially with earth, trash, or both.

Montmorillonite. A fine, platy, alumino-silicate clay mineral that expands and contracts with the absorption and loss of water. It has a high cation-exchange capacity and is plastic and sticky when moist.

Mottling, soil. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: abundance—*few*, *common*, and *many;* size—*fine*, *medium*, and *coarse;* and contrast—*faint*, *distinct*, and *prominent*. The size measurements are these: *fine*, less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium*, ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse*, more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Nutrient, plant. Any element taken in by a plant, essential to its growth, and used by it in the production of food and tissue. Nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, zinc, and perhaps other elements obtained from the soil and carbon, hydrogen, and oxygen obtained largely from the air and water, are plant nutrients.

Organic matter. A general term for plant and animal material, in or on the soil, in all stages of decomposition. Readily decomposed organic matter is often distinguished from the more stable forms that are past the stage of rapid decomposition.

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

Permeability. The quality that enables the soil to transmit water or air. Terms used to describe permeability are as follows: *very slow*, *slow*, *moderately slow*, *moderate*, *moderately rapid*, *rapid*, and *very rapid*.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline	9.1 and higher

Runoff (hydraulics). The part of the precipitation upon a drainage area that is discharged from the area in stream channels. The water that flows off the land surface without sinking in is called surface runoff; that which enters the ground before reaching surface streams is called groundwater runoff or seepage flow from ground water.

Saline soil. A soil that contains soluble salts in amounts that impair growth of plants but that does not contain excess exchangeable sodium.

Sand. Individual rock or mineral fragments in a soil that range in diameter from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Series, soil. A group of soils developed from a particular type of parent material and having genetic horizons that, except for texture of the surface layer, are similar in differentiating characteristics and in arrangement in the profile.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

Stone line. A concentration of coarse rock fragments in soils that generally represents an old weathering surface. In a cross section, the line may be one stone or more thick. The line generally overlies material that weathered in place, and it is ordinarily overlain by sediment of variable thickness.

Stripcropping. Growing crops in a systematic arrangement of strips, or bands, to serve as vegetative barriers to wind and water erosion.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single grained* (each grain by itself, as in dune sand) or *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Stubble mulch. Stubble or other crop residues left on the soil, or partly worked into the soil, to provide protection from wind and water erosion after harvest, during preparation of a seedbed for the next crop, and during the early growing period of the new crop.

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. Technically, the part of the soil below the solum.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand*, *loamy sand*, *sandy loam*, *loam*, *silt loam*, *silt*, *sandy clay loam*, *clay loam*, *silty clay loam*, *sandy clay*, *silty clay*, and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Tilth, soil. The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Varved. A distinct bond representing the annual deposit in sedimentary materials regardless of origin and ususally consisting of two layers, one a thick light colored layer of silt and fine sand and the other a thin dark colored layer of clay.

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and that of the soil series to which the mapping unit belongs. In referring to a capability unit, read the introduction to the section it is in for general information about its management.

Map symbol	Mapping unit	Described on page	Capability unit		Windbreak suitability group
			Symbol	Page	Number
Ar	Arveson fine sandy loam	13	IIIew-3	74	2
As	Arveson loam	13	IIw-4L	72	2
AvB	Arvilla sandy loam, 1 to 6 percent slopes	14	IIIes-3	74	6
Bd	Bearden silt loam, saline	15	IIIs-4L	75	10
Be	Bearden silty clay loam	15	IIe-4L	69	1
Bg	Bearden silty clay loam, clay substratum	16	IIe-4L	69	1
Bn	Bearden-Lindaas silty clay loams	16	IIew-4L	70	--
	Bearden part	--	-------	--	1
	Lindaas part	--	-------	--	2
Bo	Bearden-Overly silty clay loams	17	IIe-4L	69	1
Bp	Bearden-Perella silty clay loams	17	IIew-4L	70	--
	Bearden part	--	-------	--	1
	Perella part	--	-------	--	2
Bs	Bearden and Glyndon silt loams	17	IIe-4L	69	1
Bt	Beotia silt loam	19	IIc-6	73	1
Bu	Bohnsack loam	19	IIe-4L	69	1
Bv	Bohnsack-Tiffany loams	19	IIew-4L	70	--
	Bohnsack part	--	-------	--	1
	Tiffany part	--	-------	--	2
Bw	Borup silt loam	20	IIw-4L	72	2
Bx	Borup silt loam, saline	21	IIIs-4L	75	10
CaA	Cashel silty clay, 1 to 3 percent slopes	21	IIs-4	72	1
CaC	Cashel silty clay, channeled	21	VIw-4	77	1
Co	Colvin silt loam	22	IIw-4L	72	2
Cs	Colvin silt loam, saline	22	IIIs-4L	75	10
Cu	Cut and fill land	23	IIw-4L	72	2
Dd	Divide loam	24	IIIs-6	76	1
Do	Doran clay loam	24	IIc-6	73	1
Dv	Dovray silty clay	25	IIIw-4	74	2
EdA	Egeland loam, 1 to 3 percent slopes	26	IIe-5	69	5
EgA	Egeland-Embden fine sandy loams, 1 to 3 percent slopes	26	IIIe-3	73	--
	Egeland part	--	-------	--	5
	Embden part	--	-------	--	1
EgB	Egeland-Embden fine sandy loams, 3 to 6 percent slopes	27	IIIe-3	73	--
	Egeland part	--	-------	--	5
	Embden part	--	-------	--	1
Em	Embden fine sandy loam	27	IIIe-3	73	1
En	Embden very fine sandy loam	28	IIe-5	69	1
Eo	Emrick loam	28	IIe-5	69	1
EpA	Emrick-Heimdal loams, 1 to 3 percent slopes	28	IIe-5	69	--
	Emrick part	--	-------	--	1
	Heimdal part	--	-------	--	3
FaA	Fairdale silt loam, 1 to 3 percent slopes	30	IIc-6	73	1
Fb	Fargo silty clay loam	31	IIw-6	72	1
Fc	Fargo silty clay	31	IIew-4	69	1
Fd	Fargo-Dovray silty clays	31	IIw-4	71	--
	Fargo part	--	-------	--	1
	Dovray part	--	-------	--	2
Fe	Fargo-Enloe silty clay loams	32	IIw-6	72	--
	Fargo part	--	-------	--	1
	Enloe part	--	-------	--	2
Fg	Fargo-Enloe silty clays	32	IIw-4	71	--
	Fargo part	--	-------	--	1
	Enloe part	--	-------	--	2

GUIDE TO MAPPING UNITS--Continued

Map symbol	Mapping unit	Described on page	Capability unit		Windbreak suitability group
			Symbol	Page	Number
Fh	Fargo-Hegne silty clays	33	IIew-4	69	1
Fn	Fargo-Ryan silty clays	33	IIIs-4P	75	--
	Fargo part	--	-------	--	1
	Ryan part	--	-------	--	9
Ga	Galchutt-Fargo complex	34	IIw-6	72	1
Gd	Gardena silt loam	34	IIe-5	69	1
GeB	Gardena-Eckman silt loams, 3 to 6 percent slopes	34	IIe-5	69	--
	Gardena part	--	-------	--	1
	Eckman part	--	-------	--	3
GfC	Gardena-Zell silt loams, 6 to 9 percent slopes	35	IIIe-5	73	--
	Gardena part	--	-------	--	3
	Zell part	--	-------	--	8
Gg	Gilby loam	36	IIe-4L	69	1
Gh	Gilby-Tonka complex	36	IIew-4L	70	--
	Gilby part	--	-------	--	1
	Tonka part	--	-------	--	2
Gk	Gilby-Tonka complex, saline	36	IIIs-4L	75	--
	Gilby part	--	-------	--	10
	Tonka part	--	-------	--	2
Gm	Glyndon silt loam	37	IIe-4L	69	1
Gn	Glyndon silt loam, saline	37	IIIs-4L	75	10
Go	Glyndon-Perella silt loams	37	IIew-4L	70	--
	Glyndon part	--	-------	--	1
	Perella part	--	-------	--	2
Gr	Glyndon-Tiffany loams	37	IIew-4L	70	--
	Glyndon part	--	-------	--	1
	Tiffany part	--	-------	--	2
Gs	Grano silty clay	38	IIIw-4	74	2
GwA	Great Bend silty clay loam, 1 to 3 percent slopes	39	IIc-6	73	3
GwC	Great Bend silty clay loam, 6 to 9 percent slopes	39	IIIe-6	74	3
GwD	Great Bend silty clay loam, 9 to 15 percent slopes	39	IVe-6	76	3
Ha	Hamar loamy fine sand	40	IVew-2	76	2
Hb	Hamerly-Tonka clay loams	40	IIew-4L	70	--
	Hamerly part	--	-------	--	1
	Tonka part	--	-------	--	2
Hc	Hamerly-Tonka clay loams, saline	41	IIIs-4L	75	--
	Hamerly part	--	-------	--	10
	Tonka part	--	-------	--	2
HeA	Hecla loamy fine sand, 1 to 3 percent slopes	42	IVe-2	76	1
HfA	Hecla fine sandy loam, 1 to 3 percent slopes	42	IIIe-3	73	1
HmB	Hecla-Maddock sandy loams, 1 to 6 percent slopes	42	IIIe-3	73	--
	Hecla part	--	-------	--	1
	Maddock part	--	-------	--	5
Hn	Hegne-Enloe silty clays	43	IIew-4	69	--
	Hegne part	--	-------	--	1
	Enloe part	--	-------	--	2
Ho	Hegne-Fargo silty clays	43	IIew-4	69	1
HrB	Heimdal-Emrick loams, 3 to 6 percent slopes	44	IIe-5	69	--
	Heimdal part	--	-------	--	3
	Emrick part	--	-------	--	1
HsC	Heimdal-Esmond loams, 6 to 9 percent slopes	44	IIIe-5	73	--
	Heimdal part	--	-------	--	3
	Esmond part	--	-------	--	8
La	LaDelle silty clay loam	45	IIc-6	73	1
Lm	Lamoure silt loam	45	IIw-4L	72	2
Ln	Lankin loam	46	IIc-6	73	1
Lp	La Prairie silt loam	47	IIc-6	73	1
Lu	Ludden silty clay	48	IIIw-4	74	10
Ma	Marsh	49	VIIIw-6	78	10
Na	Nahon silt loam	50	IIIs-5P	75	9

GUIDE TO MAPPING UNITS--Continued

Map symbol	Mapping unit	Described on page	Capability unit		Windbreak suitability group
			Symbol	Page	Number
NuA	Nutley silty clay, 1 to 3 percent slopes	51	IIs-4	72	4
NuB	Nutley silty clay, 3 to 6 percent slopes	51	IIe-4	68	4
NuC	Nutley silty clay, 6 to 9 percent slopes	51	IIIe-4	73	4
NuD	Nutley silty clay, 9 to 15 percent slopes	51	IVe-4	76	4
NuE	Nutley silty clay, 15 to 25 percent slopes	51	VIe-4	77	10
Oa	Ojata silty clay loam	52	VIs-6	78	10
Or	Overly silty clay loam	53	IIc-6	73	1
Os	Overly-Fargo complex	53	IIc-6	73	1
OvB	Overly-Great Bend silty clay loams, 3 to 6 percent slopes	53	IIe-6	69	--
	Overly part	--	-------	--	1
	Great Bend part	--	-------	--	3
Pe	Perella silt loam	54	IIw-6	72	2
Pr	Playmoor silty clay loam	55	IVw-4L	77	10
ReA	Renshaw loam, 1 to 3 percent slopes	55	IIIs-5	75	6
Ro	Rockwell fine sandy loam	56	IIIew-3	74	2
SmB	Serden-Maddock loamy sands, 1 to 6 percent slopes	57	VIe-2	77	--
	Serden part	--	-------	--	7
	Maddock part	--	-------	--	5
SrB	Sioux-Arvilla complex, 1 to 6 percent slopes	58	VIs-3	77	--
	Sioux part	--	-------	--	10
	Arvilla part	--	-------	--	6
Sv	Swenoda fine sandy loam	59	IIIe-3M	73	1
Sw	Swenoda loam	59	IIe-5	69	1
Tf	Tiffany loam	60	IIw-5	72	2
To	Tonka silt loam	61	IIw-6	72	2
TrA	Towner sandy loam, 1 to 3 percent slopes	62	IIIe-3M	73	1
Un	Ulen fine sandy loam	62	IIIe-3	73	1
Vd	Vallers-Doran clay loams	63	IIw-4L	72	--
	Vallers part	--	-------	--	2
	Doran part	--	-------	--	1
Vk	Viking clay	64	IIew-4	69	1
WaA	Wahpeton silty clay, 1 to 3 percent slopes	64	IIs-4	72	1
Wh	Wheatville silt loam	65	IIe-4L	69	1
Wn	Wyndmere fine sandy loam	66	IIIe-3	73	1
Wo	Wyndmere loam	66	IIe-4L	69	1
Ws	Wyndmere loam, saline	66	IIIs-4L	75	10
Wt	Wyndmere-Tiffany fine sandy loams	66	IIIe-3	73	--
	Wyndmere part	--	-------	--	1
	Tiffany part	--	-------	--	2
ZeE	Zell silt loam, 9 to 25 percent slopes	67	VIe-4	77	8

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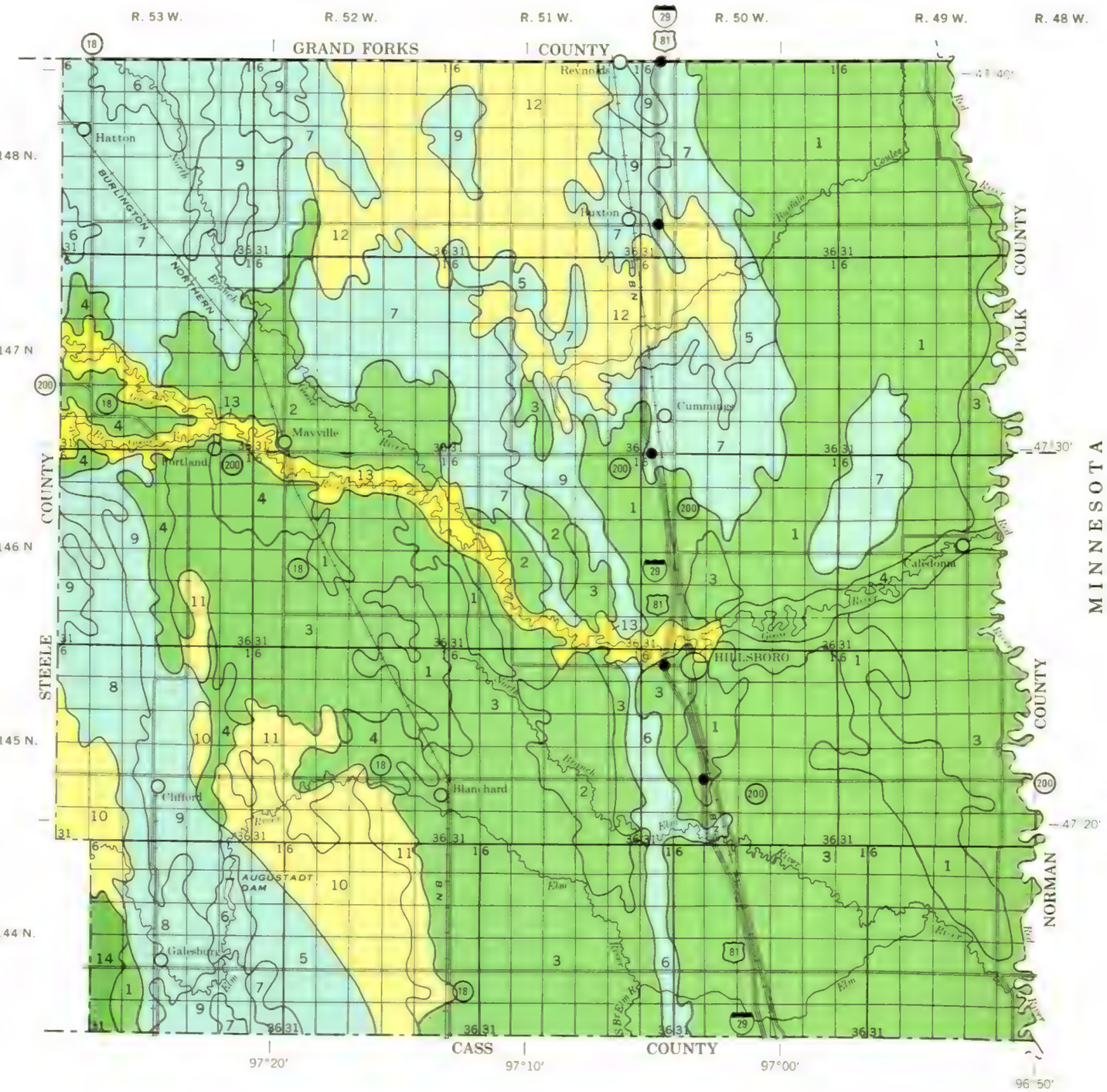
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION

GENERAL SOIL MAP
TRAILL COUNTY, NORTH DAKOTA

Scale 1:253,440
1 0 1 2 3 4 Miles

N



SOIL ASSOCIATIONS

SOILS ON GLACIAL LAKE PLAINS

1 — Bearden association: Nearly level, deep, somewhat poorly drained, moderately fine textured soils

2 — Fargo-Bearden-Galchutt association: Nearly level, deep, poorly drained and somewhat poorly drained, fine textured and moderately fine textured soils

3 — Fargo-Hegne association: Nearly level, deep, poorly drained, fine textured soils

4 — Overly-Beotia-Bearden association: Nearly level, deep, well drained to somewhat poorly drained, moderately fine textured and medium textured soils

SOILS ON DELTAS AND BEACHES

5 — Arvilla-Wyndmere-Embden association: Nearly level to sloping, shallow and moderately deep over sand and gravel and deep, somewhat excessively drained to somewhat poorly drained, moderately coarse textured soils

6 — Gardena-Overly association: Nearly level to sloping, deep, moderately well drained, medium textured and moderately fine textured soils

7 — Glyndon association: Nearly level, deep, somewhat poorly drained, medium textured soils

8 — Hecla-Arveson association: Nearly level to gently sloping, deep, moderately well drained and poorly drained, coarse textured and medium textured soils

9 — Wyndmere-Embden association: Nearly level, deep, somewhat poorly drained and moderately well drained, moderately coarse textured soils

SOILS ON INTERBEACH AREAS

10 — Bohnsack-Lankin association: Nearly level, deep, somewhat poorly drained and moderately well drained, medium textured soils

11 — Doran-Viking association: Nearly level, deep, somewhat poorly drained and poorly drained, moderately fine textured and fine textured soils

12 — Hamerly-Gilby-Tonka association: Nearly level, deep, somewhat poorly drained and poorly drained, moderately fine textured and medium textured soils

SOILS ON BREAKS AND BOTTOM LAND

13 — La Prairie-Nutley-Fairdale association: Nearly level to moderately steep, deep, moderately well drained and well drained, medium textured and fine textured soils

SOILS ON GLACIAL TILL PLAINS

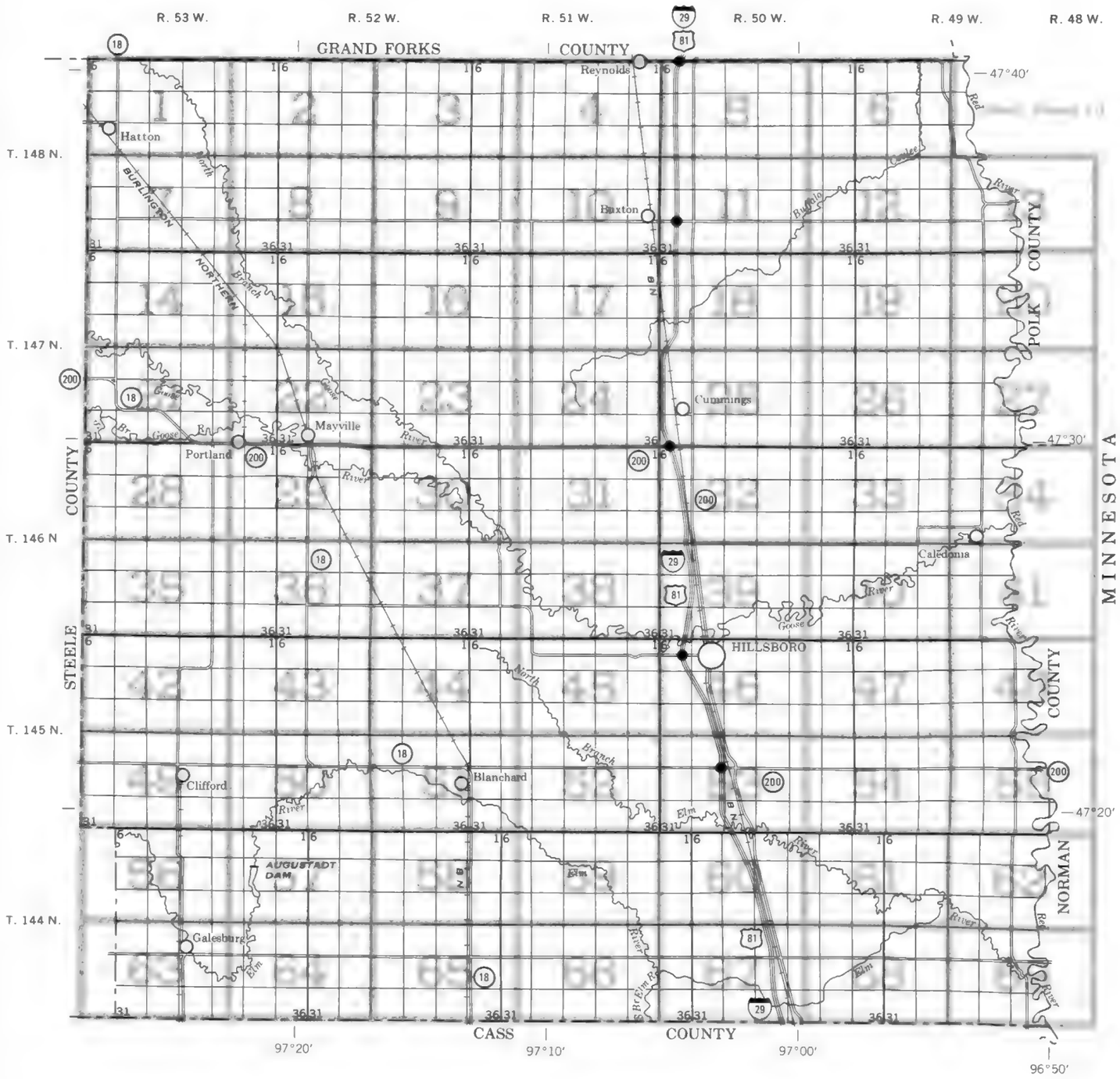
14 — Emrick-Heimdal association: Nearly level to rolling, deep, moderately well drained and well drained, medium textured soils

Compiled 1976

SECTIONALIZED TOWNSHIP

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

Each area outlined on this map consists of more than one kind of soil. The map is thus meant for general planning rather than a basis for decisions on the use of specific tracts.



INDEX TO MAP SHEETS

TRAILL COUNTY, NORTH DAKOTA

Scale 1:253,440

1 0 1 2 3 4 Miles

SECTIONALIZED TOWNSHIP

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

SOIL LEGEND

The first capital letter is the initial one of the soil name. The lower case letter that follows separates mapping units having names that begin with the same letter except that it does not separate slope phases. A second capital letter A, B, C, D, or E shows the slope. Symbols without a slope letter are for soils that are nearly level.

SYMBOL	NAME
Ar	Arveson fine sandy loam
As	Arveson loam
AvB	Arvilla sandy loam, 1 to 6 percent slopes
Bd	Bearden silt loam, saline
Be	Bearden silty clay loam
Bg	Bearden silty clay loam, clay substratum
Bn	Bearden-Lindaas silty clay loams
Bo	Bearden-Overly silty clay loams
Bp	Bearden-Perella silty clay loams
Bs	Bearden and Glyndon silt loams
Bt	Beotia silt loam
Bu	Bohnsack loam
Bv	Bohnsack-Tiffany loams
Bw	Borup silt loam
Bx	Borup silt loam, saline
CaA	Cashel silty clay, 1 to 3 percent slopes
CaC	Cashel silty clay, channeled
Co	Colvin silt loam
Cs	Colvin silt loam, saline
Cu	Cut and fill land
Dd	Divide loam
Do	Doran clay loam
Dv	Dovray silty clay
EdA	Egeland loam, 1 to 3 percent slopes
EgA	Egeland-Embden fine sandy loams, 1 to 3 percent slopes
EgB	Egeland-Embden fine sandy loams, 3 to 6 percent slopes
Em	Embden fine sandy loam
En	Embden very fine sandy loam
Eo	Emrick loam
EpA	Emrick-Heimdal loams, 1 to 3 percent slopes
FaA	Fairdale silt loam, 1 to 3 percent slopes
Fb	Fargo silty clay loam
Fc	Fargo silty clay
Fd	Fargo-Dovray silty clays
Fe	Fargo-Enloe silty clay loams
Fg	Fargo-Enloe silty clays
Fh	Fargo-Hegne silty clays
Fn	Fargo-Ryan silty clays
Ga	Galchutt-Fargo complex
Gd	Gardena silt loam
GeB	Gardena-Eckman silt loams, 3 to 6 percent slopes
GfC	Gardena-Zell silt loams, 6 to 9 percent slopes
Gg	Gilby loam
Gh	Gilby-Tonka complex
Gk	Gilby-Tonka complex, saline
Gm	Glyndon silt loam
Gn	Glyndon silt loam, saline
Go	Glyndon-Perella silt loams
Gr	Glyndon-Tiffany loams
Gs	Grano silty clay
Gp	Gravel pits
GwA	Great Bend silty clay loam, 1 to 3 percent slopes
GwC	Great Bend silty clay loam, 6 to 9 percent slopes
GwD	Great Bend silty clay loam, 9 to 15 percent slopes
Ha	Hamar loamy fine sand
Hb	Hamerly-Tonka clay loams
Hc	Hamerly-Tonka clay loams, saline
HeA	Hecla loamy fine sand, 1 to 3 percent slopes
HfA	Hecla fine sandy loam, 1 to 3 percent slopes
HmB	Hecla-Maddock sandy loams, 1 to 6 percent slopes
Hn	Hegne-Enloe silty clays
Ho	Hegne-Fargo silty clays
HrB	Heimdal-Emrick loams, 3 to 6 percent slopes
HsC	Heimdal-Esmond loams, 6 to 9 percent slopes
La	LaDelle silty clay loam
Lm	Lamoure silt loam
Ln	Lankin loam
Lp	La Prairie silt loam
Lu	Ludden silty clay
Ma	Marsh
Na	Nahon silt loam
NuA	Nutley silty clay, 1 to 3 percent slopes
	Nutley silty clay, 3 to 6 percent slopes
NuC	Nutley silty clay, 6 to 9 percent slopes
NuD	Nutley silty clay, 9 to 15 percent slopes
NuE	Nutley silty clay, 15 to 25 percent slopes
Oa	Ojata silty clay loam
Or	Overly silty clay loam
Os	Overly-Fargo complex
OvB	Overly-Great Bend silty clay loams, 3 to 6 percent slopes
Pe	Perella silt loam
Pr	Playmoor silty clay loam
ReA	Renshaw loam, 1 to 3 percent slopes
Ro	Rockwell fine sandy loam
SmB	Serden-Maddock loamy sands, 1 to 6 percent slopes
SrB	Sioux-Arvilla complex, 1 to 6 percent slopes
Sv	Swenoda fine sandy loam
Sw	Swenoda loam
Tf	Tiffany loam
To	Tonka silt loam
TrA	Towner sandy loam, 1 to 3 percent slopes
Un	Ulen fine sandy loam
Vd	Vallers-Doran clay loams
Vk	Viking clay
WaA	Wahpeton silty clay, 1 to 3 percent slopes
Wh	Wheatville silt loam
Wn	Wyndmere fine sandy loam
Wo	Wyndmere loam
Ws	Wyndmere loam, saline
Wt	Wyndmere-Tiffany fine sandy loams
ZeE	Zell silt loam, 9 to 25 percent slopes

TRAILL COUNTY, NORTH DAKOTA

CONVENTIONAL AND SPECIAL SYMBOLS LEGEND

CULTURAL FEATURES

BOUNDARIES

- National, state or province
- County or parish
- Minor civil division
- Reservation (national forest or park, state forest or park, and large airport)
- Land grant
- Limit of soil survey (label)
- Field sheet matchline & neatline

AD HOC BOUNDARY (label)

- Small airport, airfield, park, oilfield, cemetery, or flood pool

STATE COORDINATE TICK

LAND DIVISION CORNERS (sections and land grants)

ROADS

- Divided (median shown if scale permits)
- Other roads
- Trail

ROAD EMBLEMS & DESIGNATIONS

- Interstate
- Federal
- State
- County, farm or ranch

RAILROAD

POWER TRANSMISSION LINE (normally not shown)

PIPE LINE (normally not shown)

FENCE (normally not shown)

LEVEES

- Without road
- With road
- With railroad

DAMS

- Large (to scale)
- Medium or small

PITS

- Gravel pit
- Mine or quarry

MISCELLANEOUS CULTURAL FEATURES

- Farmstead, house (omit in urban areas)
- Church
- School
- Indian mound (label)
- Located object (label)
- Tank (label)
- Wells, oil or gas
- Windmill
- Kitchen midden

WATER FEATURES

DRAINAGE

- Perennial, double line
- Perennial, single line
- Intermittent
- Drainage end
- Canals or ditches
  - Double-line (label)
  - Drainage and/or irrigation

LAKES, PONDS AND RESERVOIRS

- Perennial
- Intermittent

MISCELLANEOUS WATER FEATURES

- Marsh or swamp
- Spring
- Well, artesian
- Well, irrigation
- Wet spot

SPECIAL SYMBOLS FOR SOIL SURVEY

SOIL DELINEATIONS AND SYMBOLS

ESCARPMENTS

- Bedrock (points down slope)
- Other than bedrock (points down slope)

SHORT STEEP SLOPE

GULLY

DEPRESSION OR SINK

SOIL SAMPLE SITE (normally not shown)

MISCELLANEOUS

- Blowout
- Clay spot
- Gravelly spot
- Gumbo, slick or scabby spot (sodic)
- Dumps and other similar non soil areas
- Prominent hill or peak
- Rock outcrop (includes sandstone and shale)
- Saline spot
- Sandy spot
- Severely eroded spot
- Slide or slip (tips point upslope)
- Stony spot, very stony spot

TRAILL COUNTY, NORTH DAKOTA — SHEET NUMBER 1

TRAILL COUNTY, NORTH DAKOTA NO. 1

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned

2 750 000 FEET

R. 53 W.

GRAND FORKS COUNTY

255 000 FEET

STEELE COUNTY

T. 148 N.

245 000 FEET

2 765 000 FEET

(Joins sheet 7)

(Joins sheet 2)

Hatton

BURLINGTON NORTHERN

HATTON DRAIN NO 45

North Branch Goose River

1 Mile

5 000 Feet

Scale 1:20000

(2)

N

R. 53 W. | R. 52 W | GRAND FORKS COUNTY

2 790 000 FEET

260 000 FEET

T 148 N.

1 Mile
5000 Feet
Scale 1:20000
(Joins sheet 1)

GARFIELD DRAIN NO 32

NORTH MAYVILLE DRAIN NO 6

Bethany Lutheran Church

245 000 FEET

2 770 000 FEET

(Joins sheet 8)

(Joins sheet 3)

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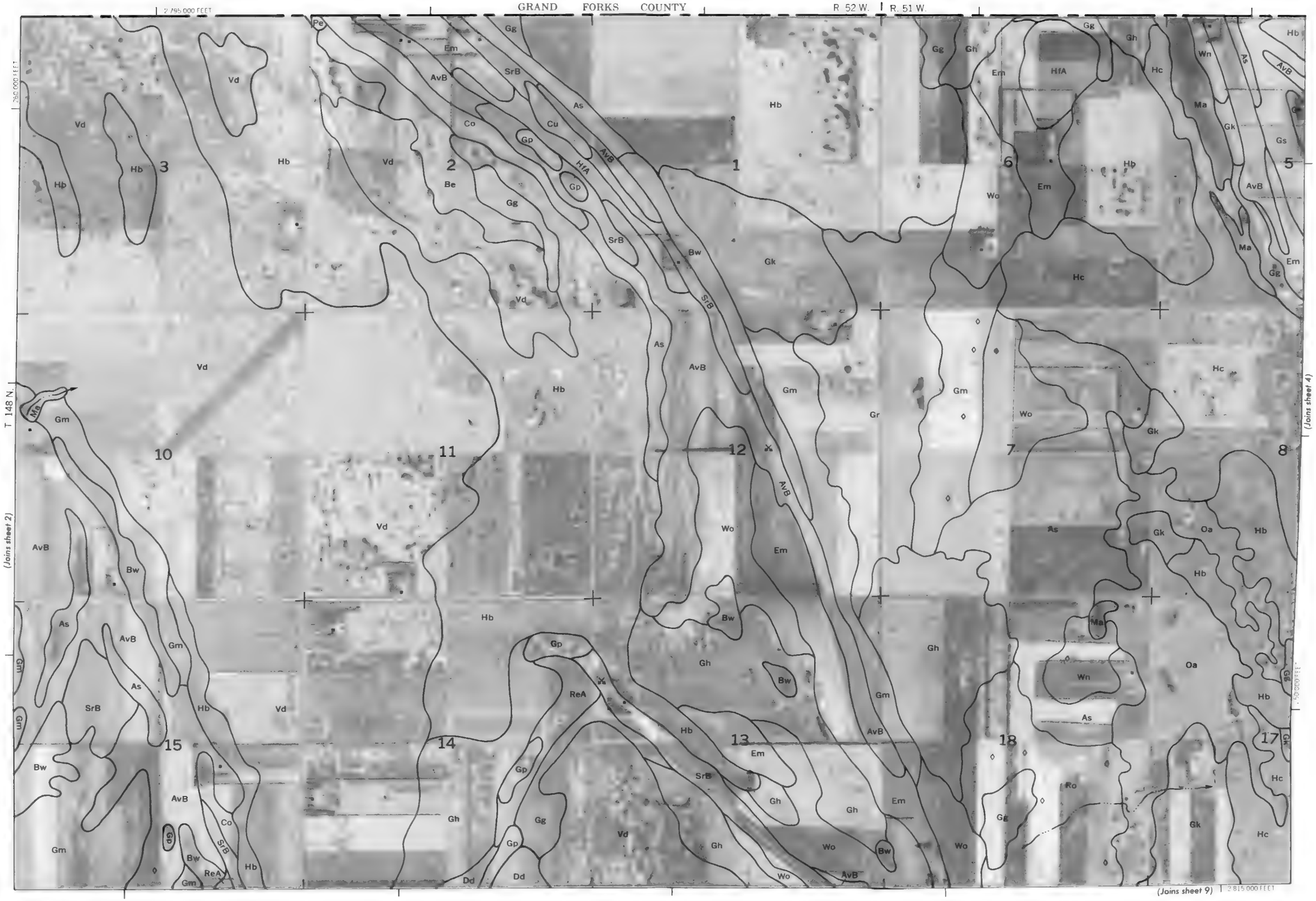
Coord nate grid lucks and land division corners if shown are approximately positioned

TRAILL COUNTY, NORTH DAKOTA NO. 2

TRAILL COUNTY, NORTH DAKOTA — SHEET NUMBER 3



TRAILL COUNTY, NORTH DAKOTA NO. 3

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Coordinate grid ticks and land division corners, if shown, are approximately positioned

TRAILL COUNTY, NORTH DAKOTA — SHEET NUMBER 4

4

N

1 Mile

5000 Feet

Scale 1:20000

0 ½ 1000 0 ¼ 2000 3000 ¾ 4000 5000

GRAND FORKS COUNTY

R 51 W

T. 148 N

Reynolds

SEWAGE LAGOON

BURLINGTON NORTHERN

(Joins sheet 3)

(Joins sheet 5)

(Joins sheet 10)

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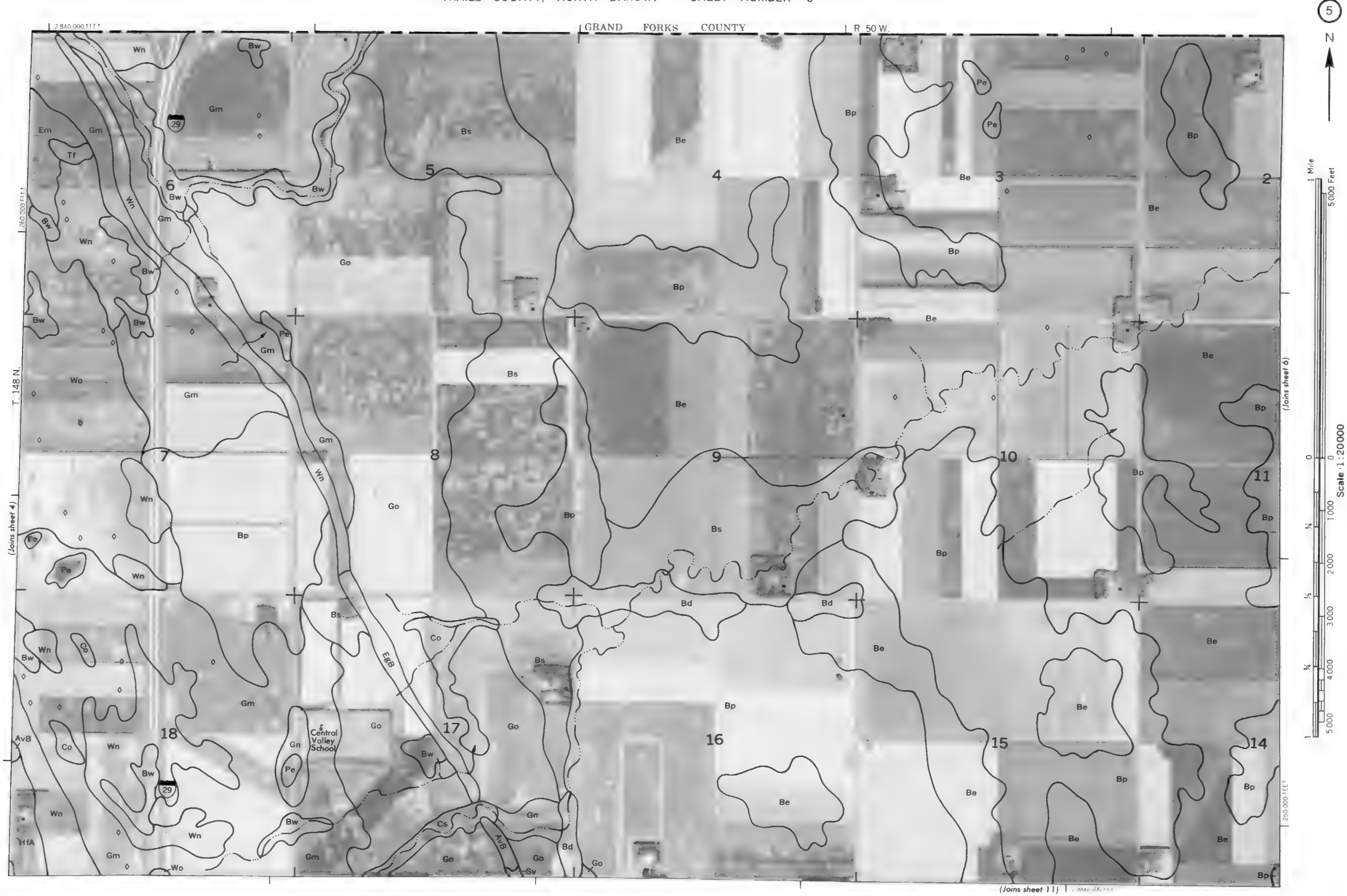
TRAILL COUNTY, NORTH DAKOTA NO. 4

TRAILL COUNTY, NORTH DAKOTA — SHEET NUMBER 5



TRAILL COUNTY, NORTH DAKOTA NO. 5

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TRAILL COUNTY, NORTH DAKOTA — SHEET NUMBER 6

6

N

R. 50 W. | R. 49 W.

GRAND FORKS COUNTY

2 885 000 FEET

265 000 FEET

T. 148 N.

250 000 FEET

2 865 000 FEET

(Joins sheet 5)

(Joins sheet 12)

(Joins sheet 13)

1 Mile

5000 Feet

Scale 1:20000

0 0 ¼ 1000 ½ 2000 ¾ 4000 1 5000

Coulee

Buffalo

Coulee

Be Bp Bs Bt GwC GwD OvB Or Pe ZeE

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

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Coordinate grid ticks and land division corners, if shown, are approximately positioned

TRAILL COUNTY, NORTH DAKOTA NO. 6

TRAILL COUNTY, NORTH DAKOTA NO. 7

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Coordinate grid ticks and land division corners, if shown, are approximately positioned

2 750 000 FEET

R. 53 W.

(Joins sheet 1)

240 000 FEET

STEELE COUNTY

T. 148 N.

HOLMAN DRAIN NO 43

NORTHERN

BURLINGTON

North Branch Goose River

SEAMAN LAGOON

(Joins sheet 8)

(Joins sheet 14)

230 000 FEET

2 770 000 FEET

19 20 21 22 23 24

30 29 28 27 26 25

31 32 33 34 35 36

1 Mile

5000 Feet

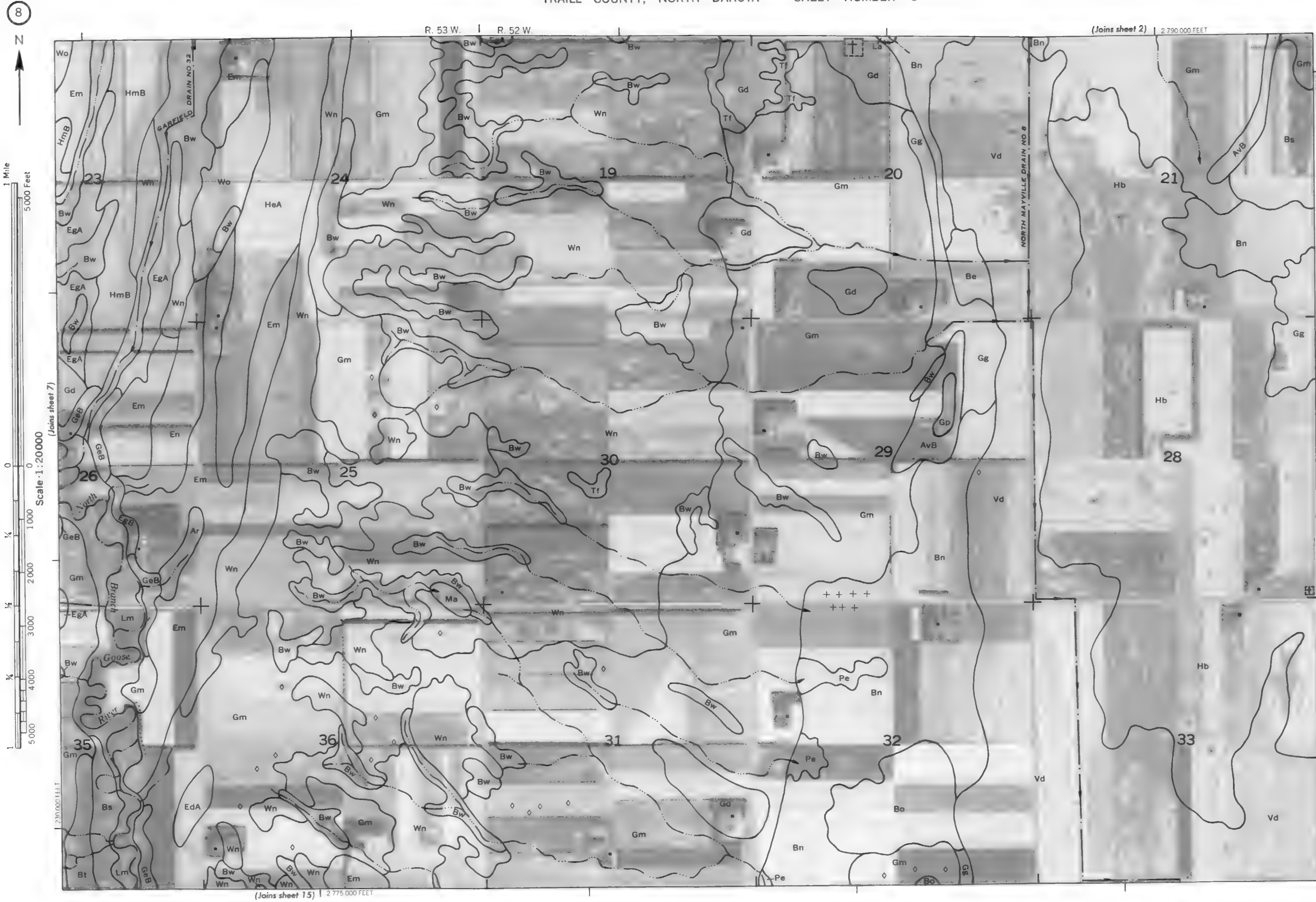
Scale 1:20000

0 ¼ ½ ¾ 1

0 1000 2000 3000 4000 5000

7

N



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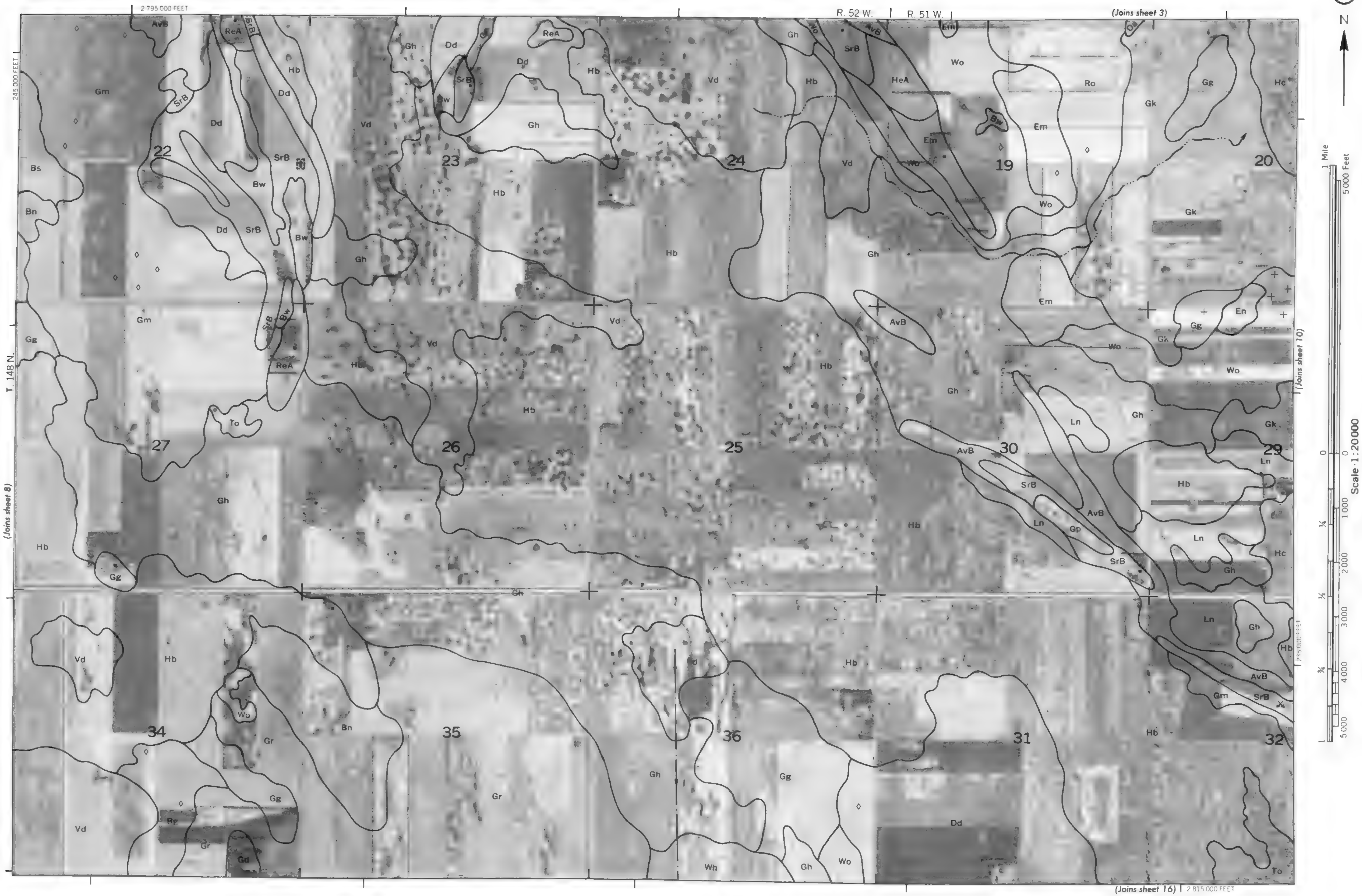
TRAILL COUNTY, NORTH DAKOTA NO. 8



TRAILL COUNTY, NORTH DAKOTA NO. 9

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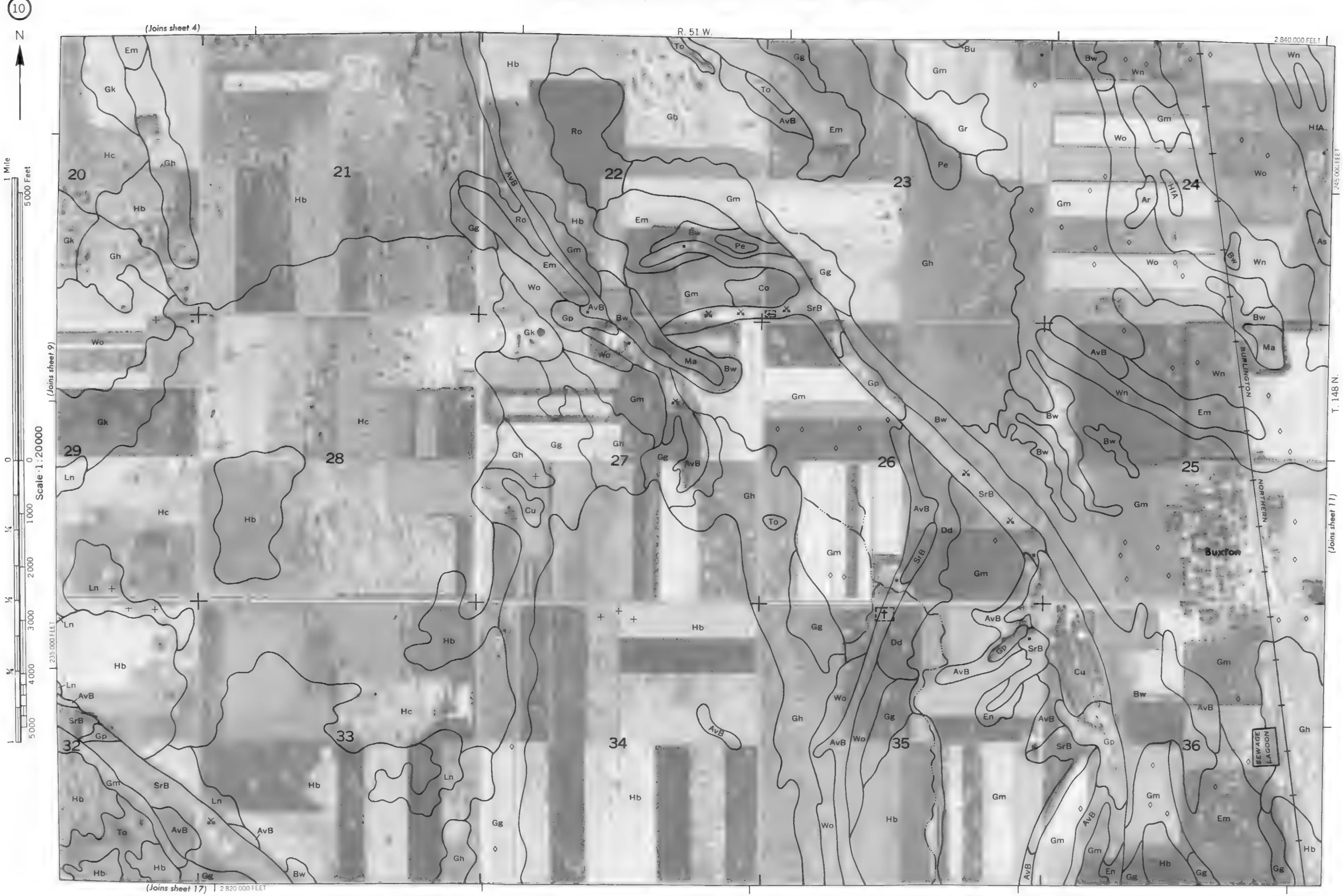

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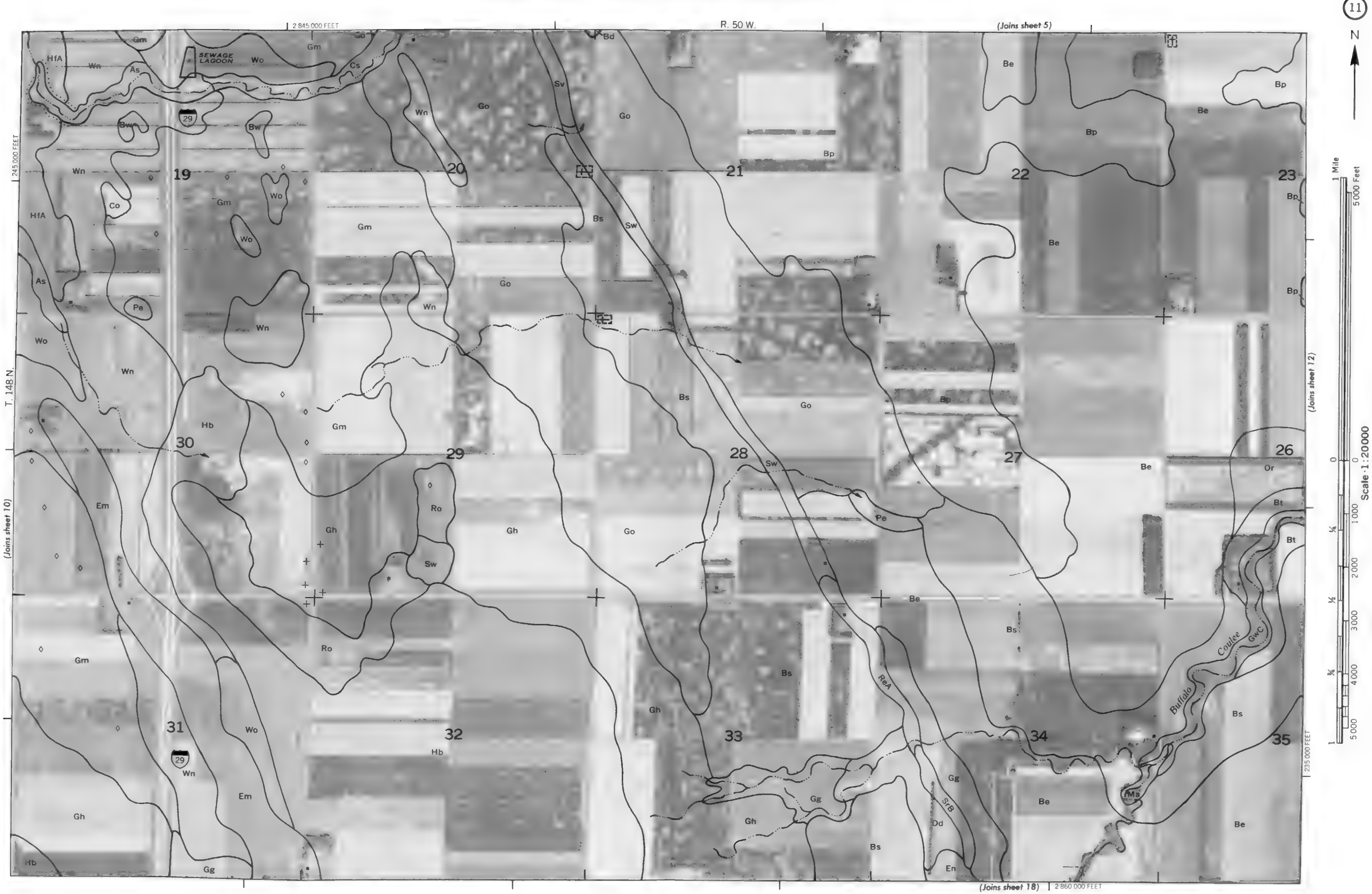
TRAILL COUNTY, NORTH DAKOTA NO. 10

TRAILL COUNTY, NORTH DAKOTA — SHEET NUMBER 11



TRAILL COUNTY, NORTH DAKOTA NO. 11

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12

N

1 Mile
5000 Feet

Scale · 1:20000

(Joins sheet 6) R. 50 W. R. 49 W. 2 885 000 FEET

(Joins sheet 11)

T. 148 N.

(Joins sheet 13)

235 000 FEET

2 865 000 FEET (Joins sheet 19)

250 000 FEET

Coulee

Buffalo

Grue Church

GwC

GwD

ZeE

OvB

CARSON DRAIN NO 10

23 24 19 20 21

26 25 30 29 28

35 36 31 32 33

Be Bp Bs Bt Or

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies
Coordinate grid ticks and land division corners if shown, are approximately positioned.

TRAILL COUNTY, NORTH DAKOTA NO. 12

TRAILL COUNTY, NORTH DAKOTA NO. 13

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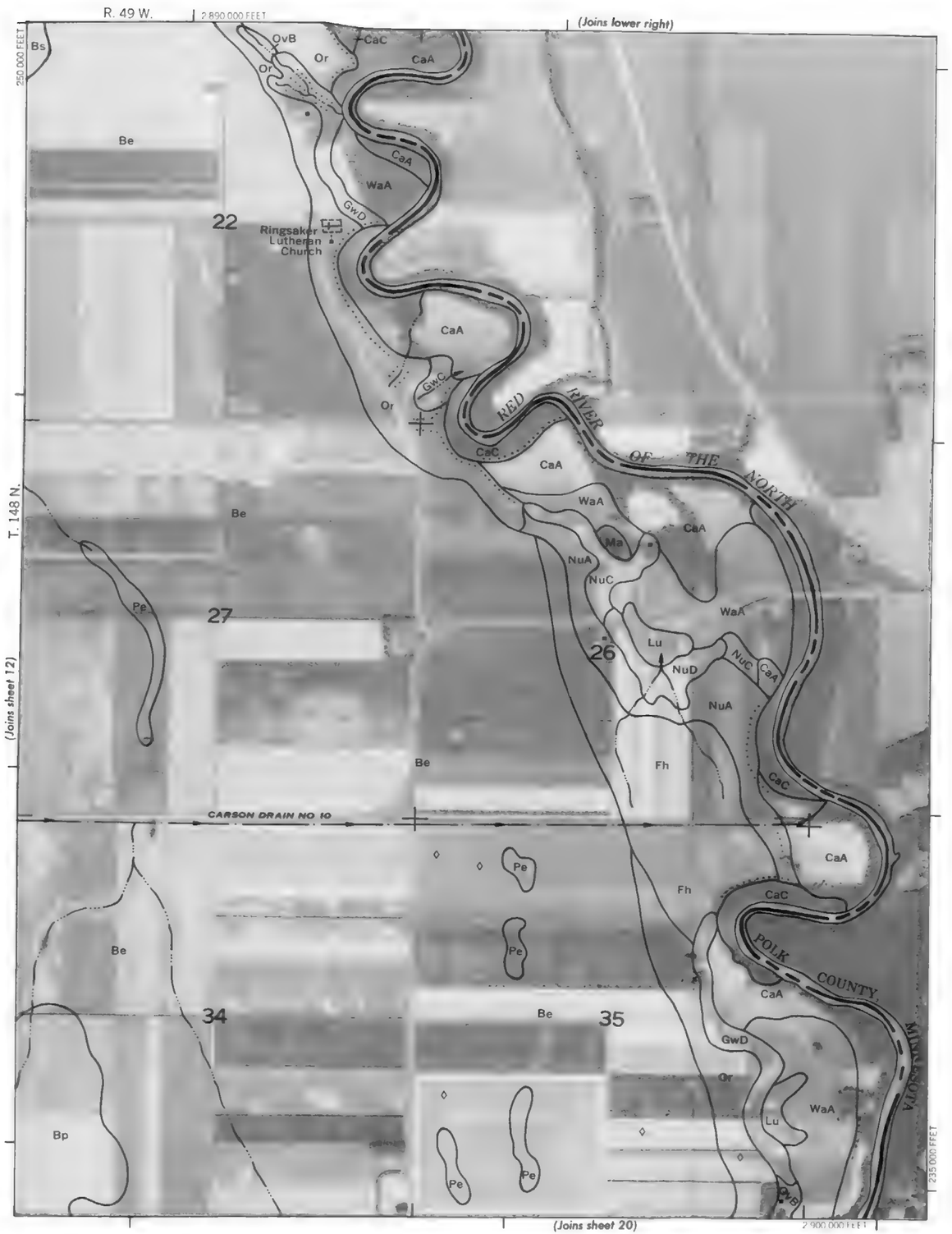
Coordinate grid ticks and land division corners, if shown, are approximately positioned.



13

N

1 Mile 5000 Feet

Scale 1:20000

0 ¼ ½ ¾ 1

5000 4000 3000 2000 1000 0

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TRAILL COUNTY, NORTH DAKOTA NO. 15

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16

N

R. 52 W. R. 51 W.

(Joins sheet 9)

2 815 000 FEET

230 000 FEET

T. 147 N.

(Joins sheet 15)

(Joins sheet 17)

(Joins sheet 23)

215 000 FEET

1 Mile 5000 Feet

Scale 1:20000

0 0 ½ 1000 ½ 2000 ¾ 3000 1 4000 1¼ 5000

Vd Gd Hb Bg Gr Pe Wn Bw Co Wh Wo Gn Dd Hb To Gg AvB SrB Gp Gm Em Gh GeB

1 2 3 5 6 7 8 10 11 12 13 14 15 17 18

NORTH MAYVILLE DRAIN NO.

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Coordinate grid ticks and land division corners, if shown, are approximately positioned

TRAILL COUNTY, NORTH DAKOTA NO. 16

TRAILL COUNTY, NORTH DAKOTA NO. 17

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies
Coordinate grid ticks and land division corners, if shown, are approximately positioned.

2 820 000 FEET

R. 51 W.

(Joins sheet 10)

230 000 FEET

T. 147 N.

(Joins sheet 16)

220 000 FEET

(Joins sheet 24)

2 840 000 FEET

(Joins sheet 18)

BURLINGTON NORTHERN

Buffalo Coulee

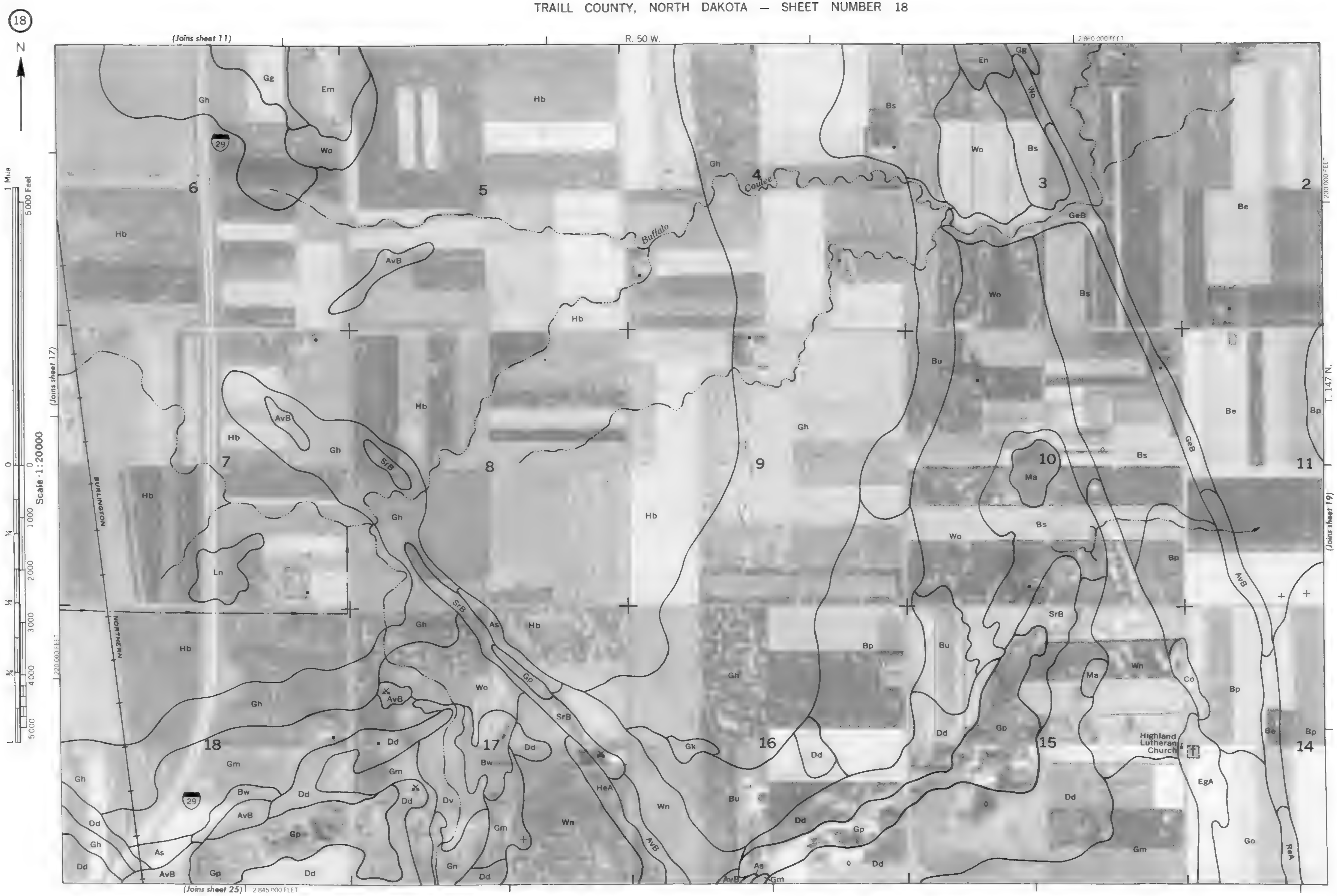
17

N

1 Mile

5000 Feet

Scale · 1 : 20000



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TRAILL COUNTY, NORTH DAKOTA NO. 19

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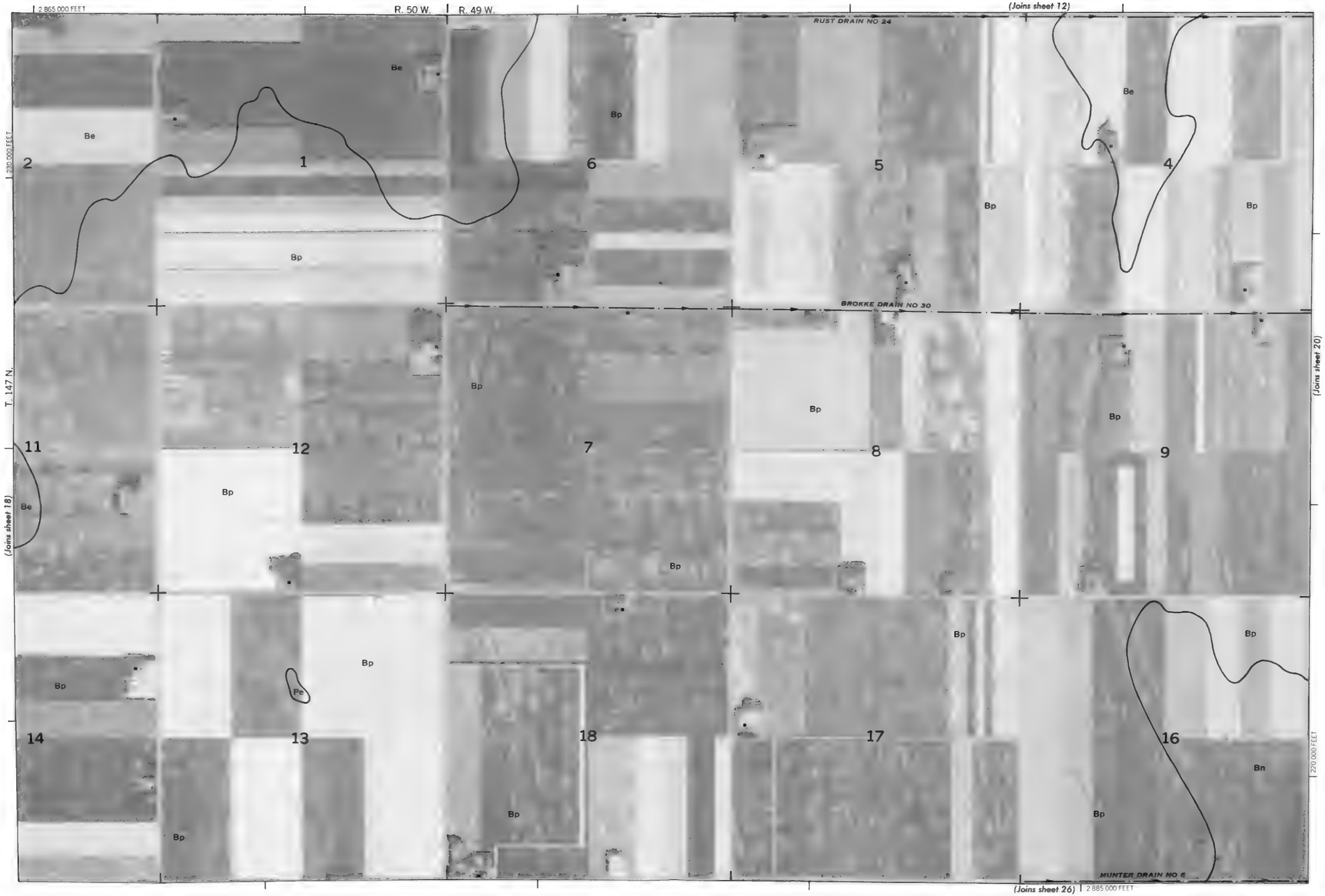

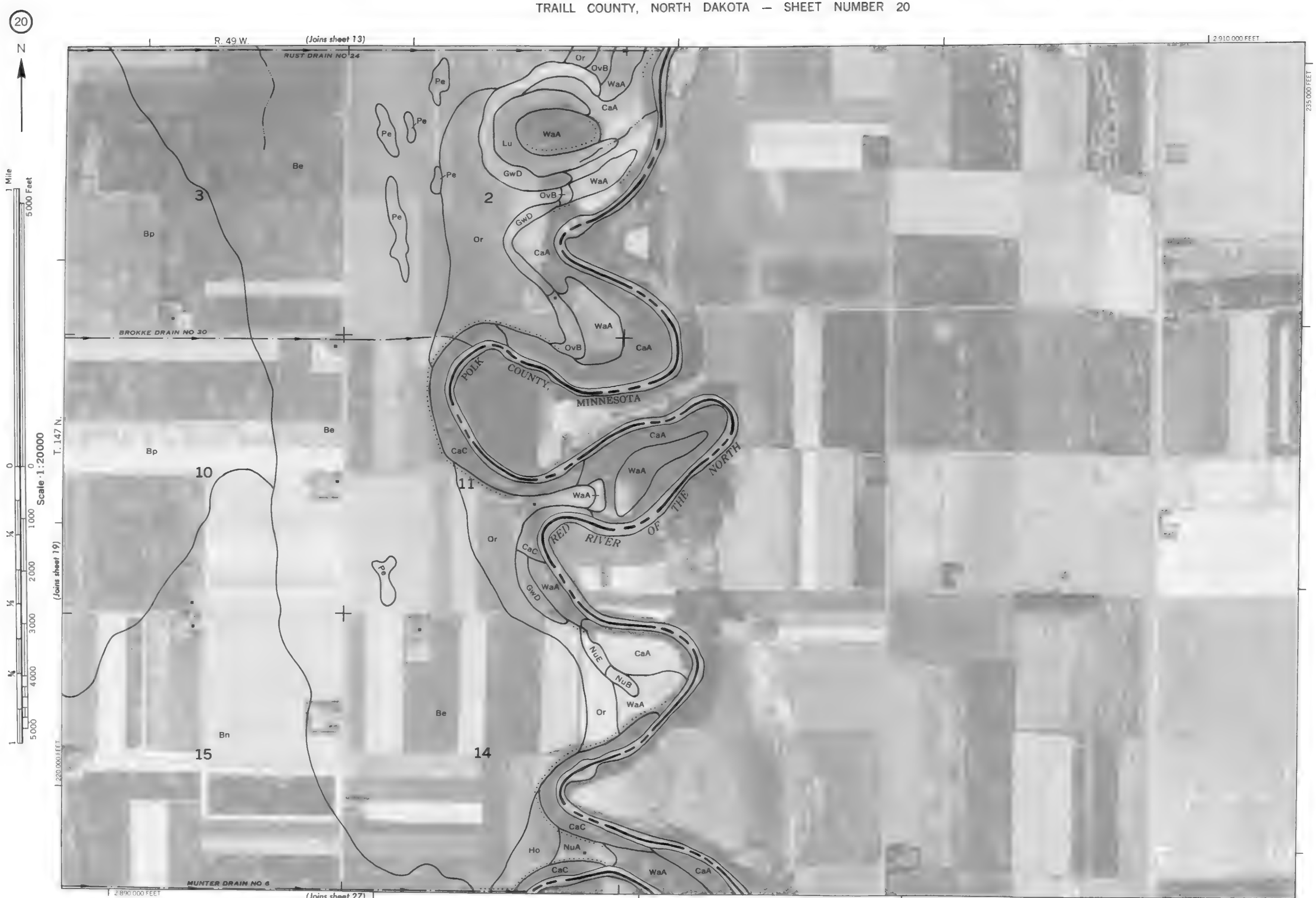

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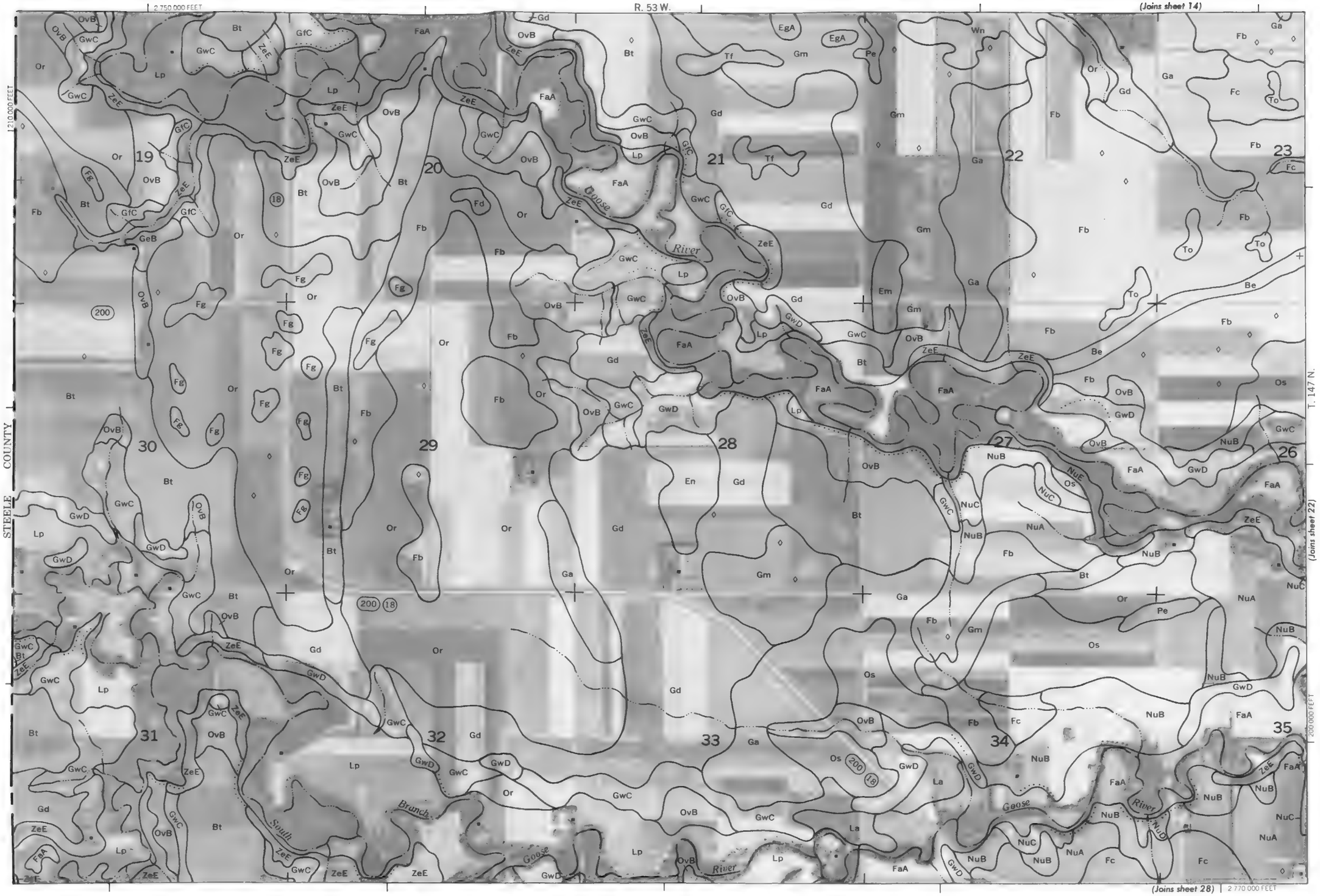
TRAILL COUNTY, NORTH DAKOTA NO. 20



TRAILL COUNTY, NORTH DAKOTA NO. 21

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Coordinate grid ticks and land division corners, if shown, are approximately positioned

TRAILL COUNTY, NORTH DAKOTA — SHEET NUMBER 22

22

N

(Joins sheet 15)

R. 53 W. | R. 52 W.

2 790 000 FEET

T. 147 N.

210 000 FEET

(Joins sheet 21)

200 000 FEET

(Joins sheet 23)

(Joins sheet 29) | 2 775 000 FEET

1 Mile

5 000 Feet

Scale 1:20000

0 1000 2000 3000 4000 5000

NORTH MAYVILLE DRAIN NO 44

BURLINGTON NORTHERN

Goose River

North La Branch

Portland

MAYVILLE

23 24 19 20 21 26 25 30 29 28 35 36 31 32 33

Fb Ga Fc Gm Fh Bg Be Os Fg NuB NuC GeB NuE La OvB Wh Pe Wg To GwC GwD Bs Or ZeE NuA FaA Bo Ds NuD

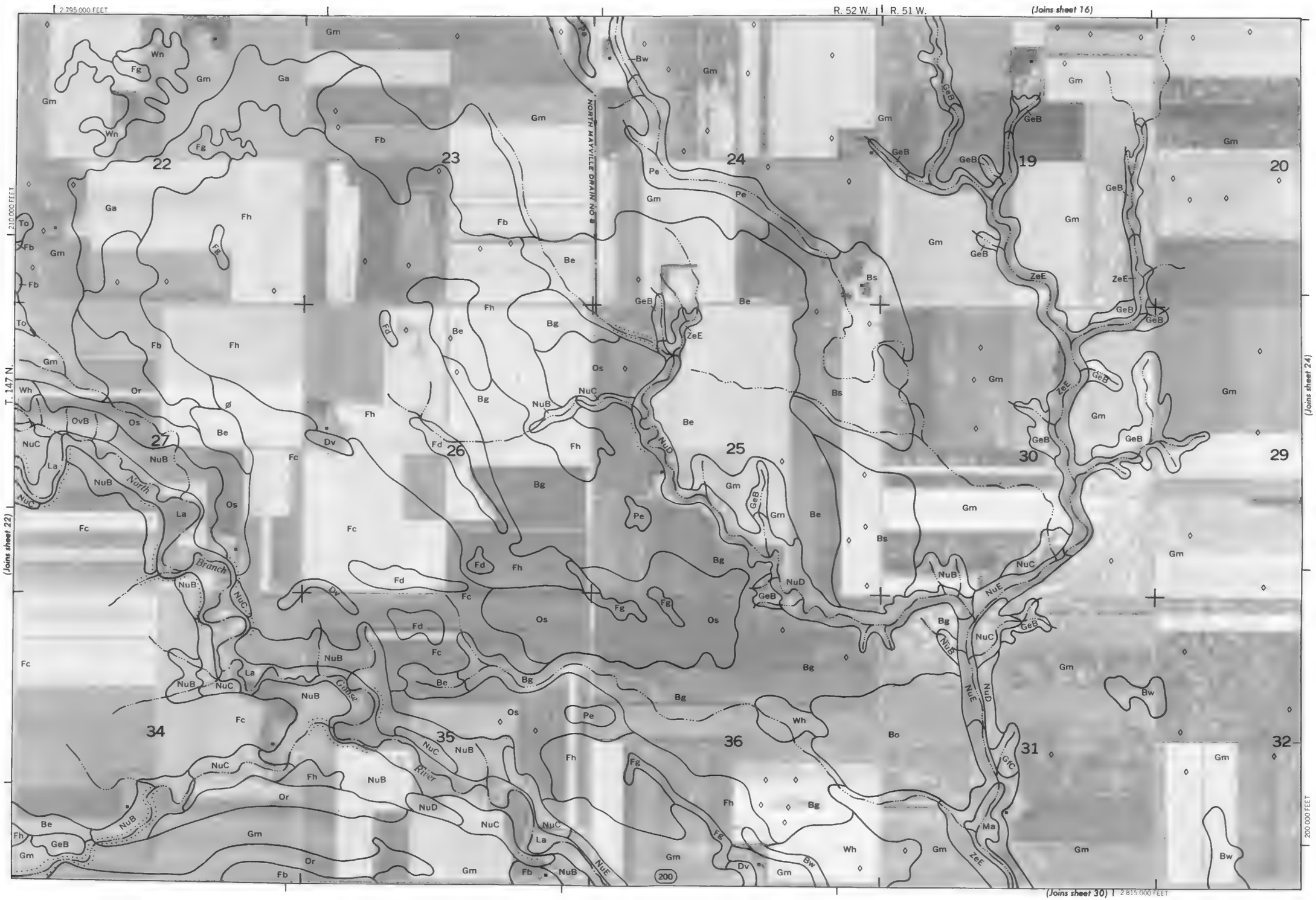
(200) (18)

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies
Coordinate grid ticks and land division corners, if shown, are approximately positioned

TRAILL COUNTY, NORTH DAKOTA NO. 22

TRAILL COUNTY, NORTH DAKOTA NO. 23

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture Soil Conservation Service and cooperating agencies
Coordinate grid ticks and land division corners, if shown, are approximately positioned



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Coordinate grid ticks and land division corners, if shown, are approximately positioned.

TRAILL COUNTY, NORTH DAKOTA NO. 25

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies
Coordinate grid ticks and land division corners, if shown, are approximately positioned

2 845 000 FEET

R. 50 W.

(Joins sheet 18)

215 000 FEET

(Joins sheet 24)

T. 147 N.

205 000 FEET

(Joins sheet 26)

(Joins sheet 32)

2 865 000 FEET

Cummings

BURLINGTON

NORTHERN

19 20 21 22 23

30 29 28 27 26

31 32 33 34 35

Cu Dd AvB Gp Gn Wn HeA As Ar Wo HmB Em Bx Ma ReA Bw Gm Pe Bs Go EgA Bp Bn Bd

29 200

25

N

1 Mile 5000 Feet

Scale 1:20000

0 ¼ ½ ¾ 1

0 1000 2000 3000 4000 5000

26

N

(Joins sheet 19)

R. 50 W. | R. 49 W.

2 885 000 FEET

215 000 FEET

T. 147 N.

(Joins sheet 27)

(Joins sheet 25)

205 000 FEET

(Joins sheet 33)

1 Mile

5000 Feet

Scale 1:20000

MOEN DRAIN NO 27

23 24 19 20 21

26 25 30 29 28

35 36 31 32 33

Bp Bn Go Gp Gm Cu Dd Hn

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies
Coordinate grid ticks and land division corners, if shown, are approximately positioned

TRAILL COUNTY, NORTH DAKOTA NO. 26

N

2 890 000 FEET

(Joins sheet 20)

R. 49 W.

215 000 FEET

T. 147 N.

(Joins sheet 26)

22

23

27

26

34

35

Bn

Be

Ho

NuB

NuE

NuC

NuA

NuD

CaA

CaC

WaA

Lu

Salem Lutheran Church

MOEN DRAIN NO 27

POLK COUNTY, MINNESOTA

RED RIVER OF THE NORTH

(Joins sheet 34)

205 000 FEET

2 910 000 FEET

1 Mile

5000 Feet

Scale 1:20000

TRAILL COUNTY, NORTH DAKOTA NO. 27

This map is compiled on 1974 aerial photography, by the U S Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.

28

N

(Joins sheet 21)

R. 53 W.

2 770 000 FEET

200 18

T. 146 N.

195 000 FEET

185 000 FEET

(Joins sheet 29)

(Joins sheet 35)

2 750 000 FEET

1 Mile

5000 Feet

Scale 1:20000

COUNTY

STEELE

ROSEVILLE DRAIN NO. 19

Goose River

South Branch

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture Soil Conservation Service and cooperating agencies
Coordinate grid ticks and land division corners, if shown, are approximately positioned.

TRAILL COUNTY, NORTH DAKOTA NO. 29

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies
Coordinate grid ticks and land division corners, if shown, are approximately positioned.

30

N

(Joins sheet 23)

R. 52 W. | R. 51 W.

815,000 FEET

T. 146 N.

(Joins sheet 29)

(Joins sheet 31)

1 Mile
5000 Feet
Scale 1:20000
0
1/4
1/2
3/4
1000
2000
3000
4000
5000

185,000 FEET

HANSON DRAIN NO 18

(Joins sheet 37)

2 800 000 FEET

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies
Colored nate grid ticks and land division corners - if shown, are approximately positioned.

TRAILL COUNTY, NORTH DAKOTA NO. 30

TRAILL COUNTY, NORTH DAKOTA NO. 31

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown are approximately positioned

2 820 000 FEET — R. 51 W. — (Joins sheet 24)

195 000 FEET — T. 146 N.

(Joins sheet 30) — (Joins sheet 32) — (Joins sheet 38) — 2 840 000 FEET — 185 000 FEET

NORWAY DRAIN NO 38

Norway Lutheran Church

1 Mile — 5000 Feet — Scale 1:20000

31

32

N

(Joins sheet 25)

R. 50 W.

2 865 000 FEET

200 000 FEET

T. 146 N.

(Joins sheet 31)

(Joins sheet 33)

(Joins sheet 39)

185 000 FEET

2 845 000 FEET

Scale 1:20000

1 Mile 5000 Feet

0 ¼ ½ ¾ 1

0 1000 2000 3000 4000 5000

Bd Bs Cu Gm Wn Pe Go Bg Be Bp Hn Os Fh Bn

6 5 4 3 2

7 8 9 10 11

18 17 16 15 14

29 200

BURLINGTON NORTHERN

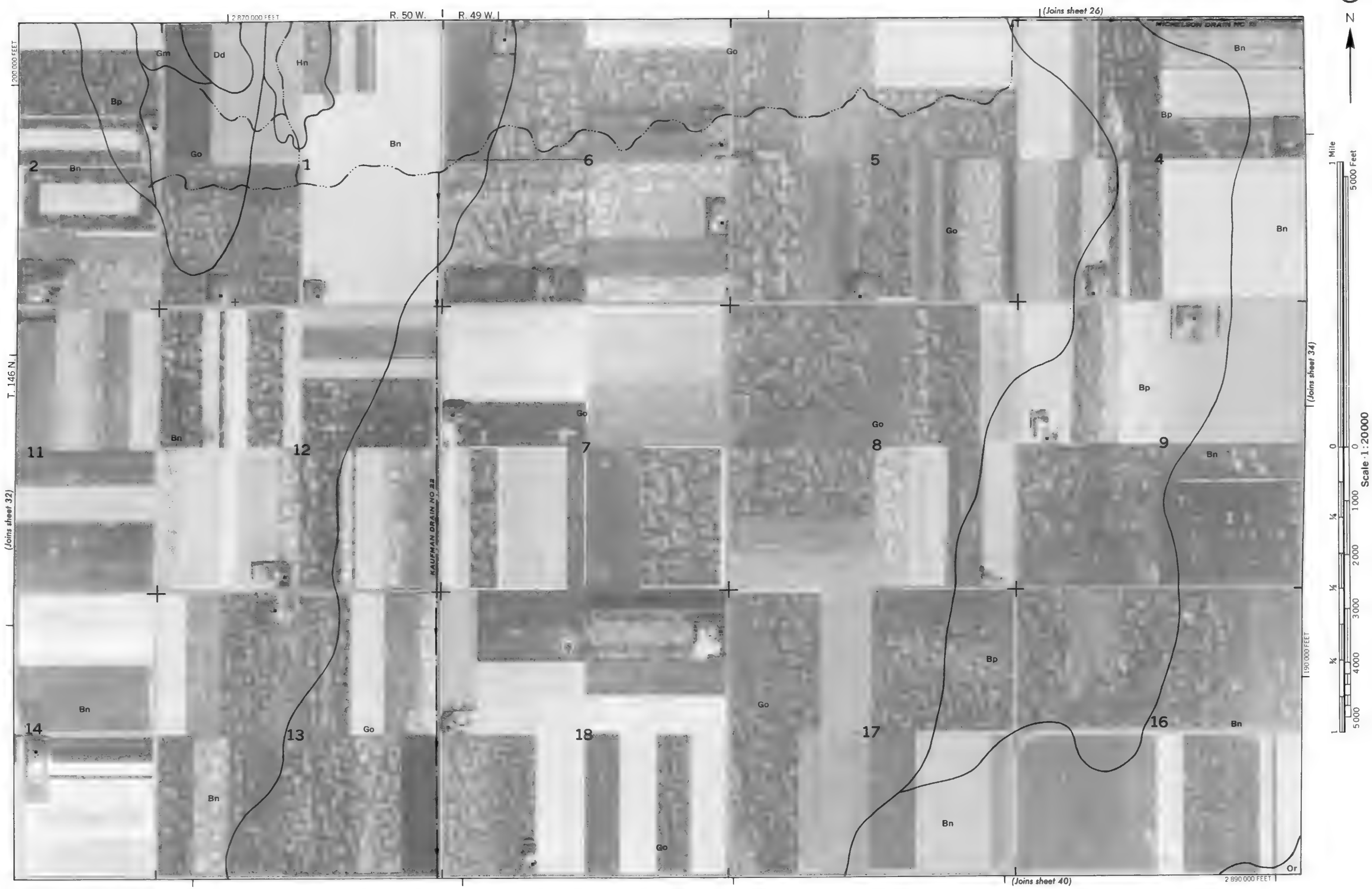
PAULSON DRAIN NO 2

St Olaf Lutheran Church

Taft

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies
Coordinate grid ticks and land division corners, if shown, are approximately positioned

TRAILL COUNTY, NORTH DAKOTA NO. 32



TRAILL COUNTY, NORTH DAKOTA NO. 33

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies
Coordinate grid ticks and land division corners, if shown, are approximately positioned

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies
Coordinate grid ticks and land division corners, if shown, are approximately positioned

TRAILL COUNTY, NORTH DAKOTA NO. 34

TRAILL COUNTY, NORTH DAKOTA NO. 35

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture Soil Conservation Service and cooperating agencies
Coordinate grid ticks and land division corners, if shown, are approximately positioned.

35

N

R. 53 W.

(Joins sheet 28)

2 750 000 FEET

180 000 FEET

T. 146 N.

STEELE COUNTY

ROSEVILLE DRAIN NO 19

Roseville

Roseville Trinity Lutheran Church

19 20 21 22 23 24 30 29 28 27 26 31 32 33 34 35

(Joins sheet 36)

170 000 FEET

(Joins sheet 42)

2 770 000 FEET

1 Mile 5000 Feet

Scale · 1 : 20000

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

TRAILL COUNTY, NORTH DAKOTA NO. 37

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture Soil Conservation Service and cooperating agencies
Coordinate grid ticks and land division corners, if shown, are approximately positioned

37

N

1 Mile
5000 Feet

Scale 1:20000

1 0 ¼ ½ ¾ 1
5000 0 1000 2000 3000 4000 5000

38

N

(Joins sheet 31)

R. 51 W.

2 840 000 FEET

180 000 FEET

T. 146 N.

(Joins sheet 39)

(Joins sheet 37)

170 000 FEET

(Joins sheet 45)

1 Mile 5 000 Feet

Scale · 1 : 20000

0 0 ¼ 1 000 ½ 2 000 ¾ 3 000 1 4 000 5 000

20 21 22 23 24 25 26 27 28 29 32 33 34 35 36

NORWAY DRAIN NO 38

Aal Church

Goose River

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies
Coordinate grid ticks and land division corners, if shown, are approximately positioned

TRAILL COUNTY, NORTH DAKOTA NO. 38

TRAILL COUNTY, NORTH DAKOTA NO. 39

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

TRAILL COUNTY, NORTH DAKOTA — SHEET NUMBER 40

40

N

(Joins sheet 33)

R. 50 W. | R. 49 W.

2 890 000 FEET

185 000 FEET

KAUFMAN DRAIN NO 22

Goose River

1 Mile 5 000 Feet

Scale 1:20000

(Joins sheet 39)

(Joins sheet 41)

T. 146 N.

(Joins sheet 47) | 2 870 000 FEET

170 000 FEET

23 24 19 20 21 26 25 30 29 28 35 36 31 32 33

Bn Go Or OvB FaA GwC GwD Bt Fc Dv Fh Ho Hn

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture. Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.

TRAILL COUNTY, NORTH DAKOTA NO. 40

(Joins sheet 34)

2 895 000 FEET

R. 49 W.

185 000 FEET

T. 146 N.

(Joins sheet 40)

(Joins sheet 48)

2 910 000 FEET

175 000 FEET

GwC Or OvB FaA Hn Fc WaA CaA NuD Lu NuE CaA NuB NuA Fh CaC

Goose River

RED RIVER OF THE NORTH

NORMAN COUNTY

MINNESOTA

22 23 27 26 34 35

N

1 Mile 5000 Feet

Scale 1:20000

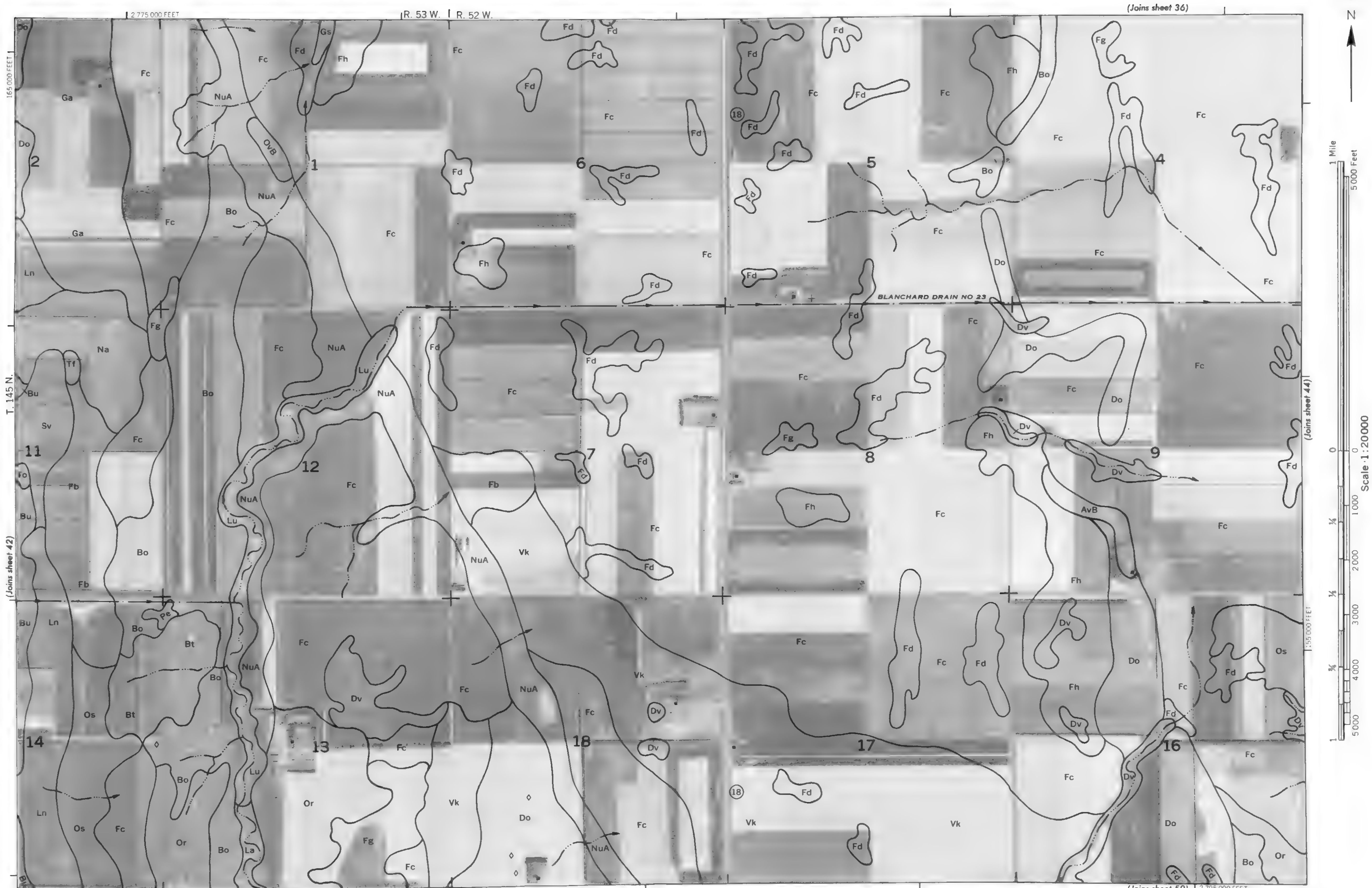
TRAILL COUNTY, NORTH DAKOTA NO. 41

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximate, y positioned

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned

TRAILL COUNTY, NORTH DAKOTA NO. 42

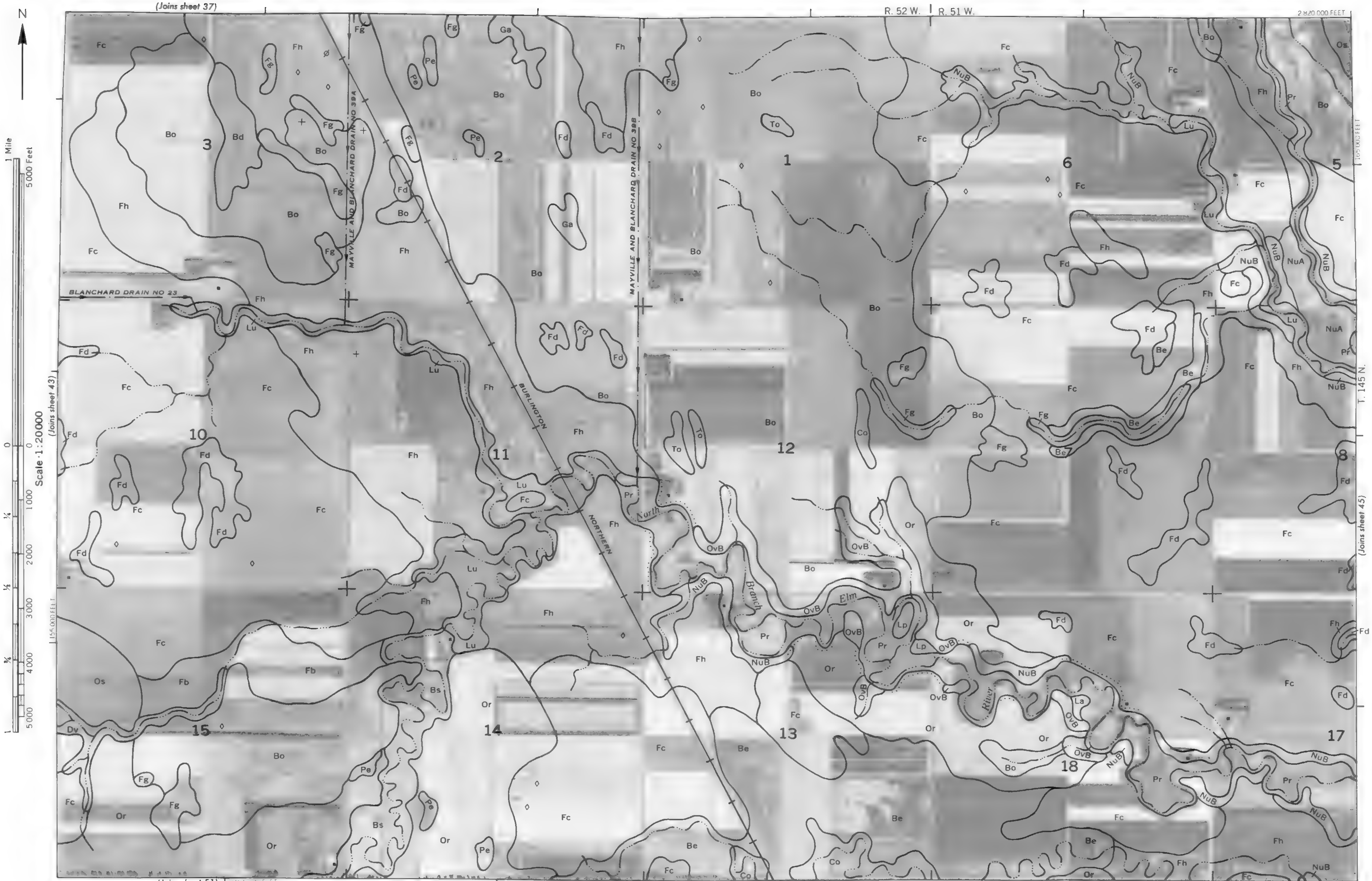
43



TRAILL COUNTY, NORTH DAKOTA NO. 43

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

TRAILL COUNTY, NORTH DAKOTA — SHEET NUMBER 44



This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

TRAILL COUNTY, NORTH DAKOTA NO. 45

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.

46

N

(Joins sheet 39)

R. 50 W

2,865,000 FEET

165,000 FEET

T. 145 N.

(Joins sheet 45)

(Joins sheet 47)

2,845,000 FEET

(Joins sheet 53)

1 Mile

5000 Feet

Scale 1:20000

HILLSBORO

BURLINGTON NORTHERN

HILLSBORO DRAIN NO 26

Goose River

Lp En NuA Fc FaA La Bn Fh Hn Fb Ga Sw Fu Or Fd Pe As Bo Gd

6 5 4 3 2 7 8 9 10 11 18 17 16 15 14

29 200

This map is compiled on 1974 aerial photography by the U S Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.

TRAILL COUNTY, NORTH DAKOTA NO. 46

TRAILL COUNTY, NORTH DAKOTA — SHEET NUMBER 47

TRAILL COUNTY, NORTH DAKOTA NO. 47

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned

2 870 000 FEET

R. 50 W.

R. 49 W.

(Joins sheet 40)

47

N

165 000 FEET

T. 145 N.

(Joins sheet 46)

(Joins sheet 48)

STEENERSON DRAIN NO 30

155 000 FEET

(Joins sheet 54)

2 890 000 FEET

1 Mile

5 000 Feet

Scale 1:20000

48

N

(Joins sheet 41)

R. 49 W.

2 910 000 FEET

170 000 FEET

1 Mile

5000 Feet

0

0

Scale · 1 : 20000

¼ 1000

½ 2000

¾ 3000

1 4000

1¼ 5000

T. 145 N.

(Joins sheet 47)

155 000 FEET

(Joins sheet 55)

2 895 000 FEET

STEENERSON DRAIN NO 20

RED RIVER OF THE NORTH

MINNESOTA

NORMAN COUNTY

Ho Fh Fc Fd NuE NuA NuB NuC CaA CaC WaA Lu Dv Bn Hn

1 2 3 10 11 12 13 14 15

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture Soil Conservation Service and cooperating agencies
Coordinate grid ticks and land division corners if shown are approximately plotted

TRAILL COUNTY, NORTH DAKOTA NO. 48

TRAILL COUNTY, NORTH DAKOTA NO. 49

This map is compiled on 1974 aerial photographs by the U. S. Department of Agriculture Soil Conservation Service and cooperating agencies
Coordinate grid ticks and land division corners if shown are approximately positioned

N

2 755 000 FEET

R. 53 W.

(Joins sheet 42)

T. 145 N.

STEELE COUNTY

BURLINGTON NORTHERN

Clifford

(Joins sheet 50)

(Joins sheet 56)

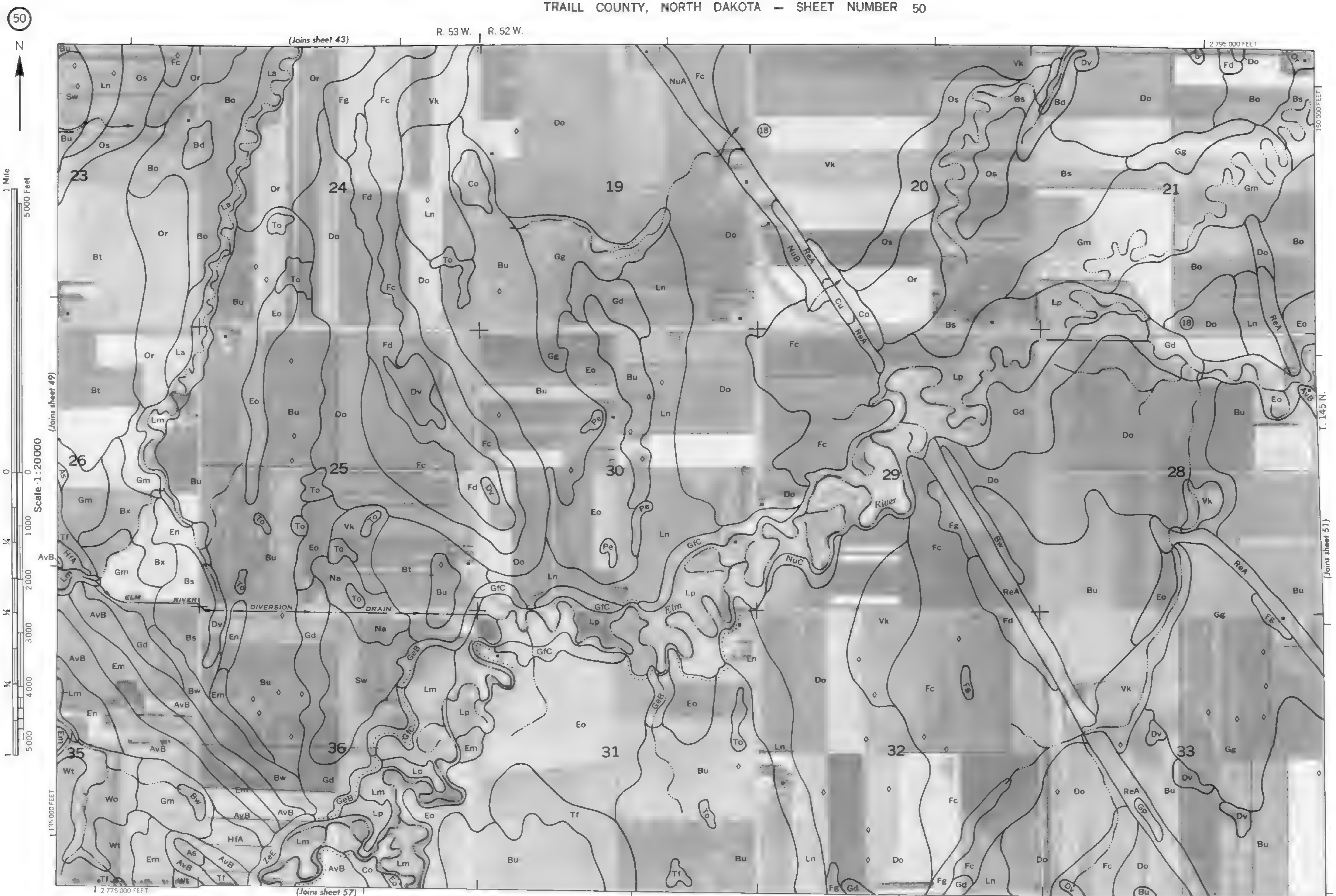
2 770 000 FEET

135 000 FEET

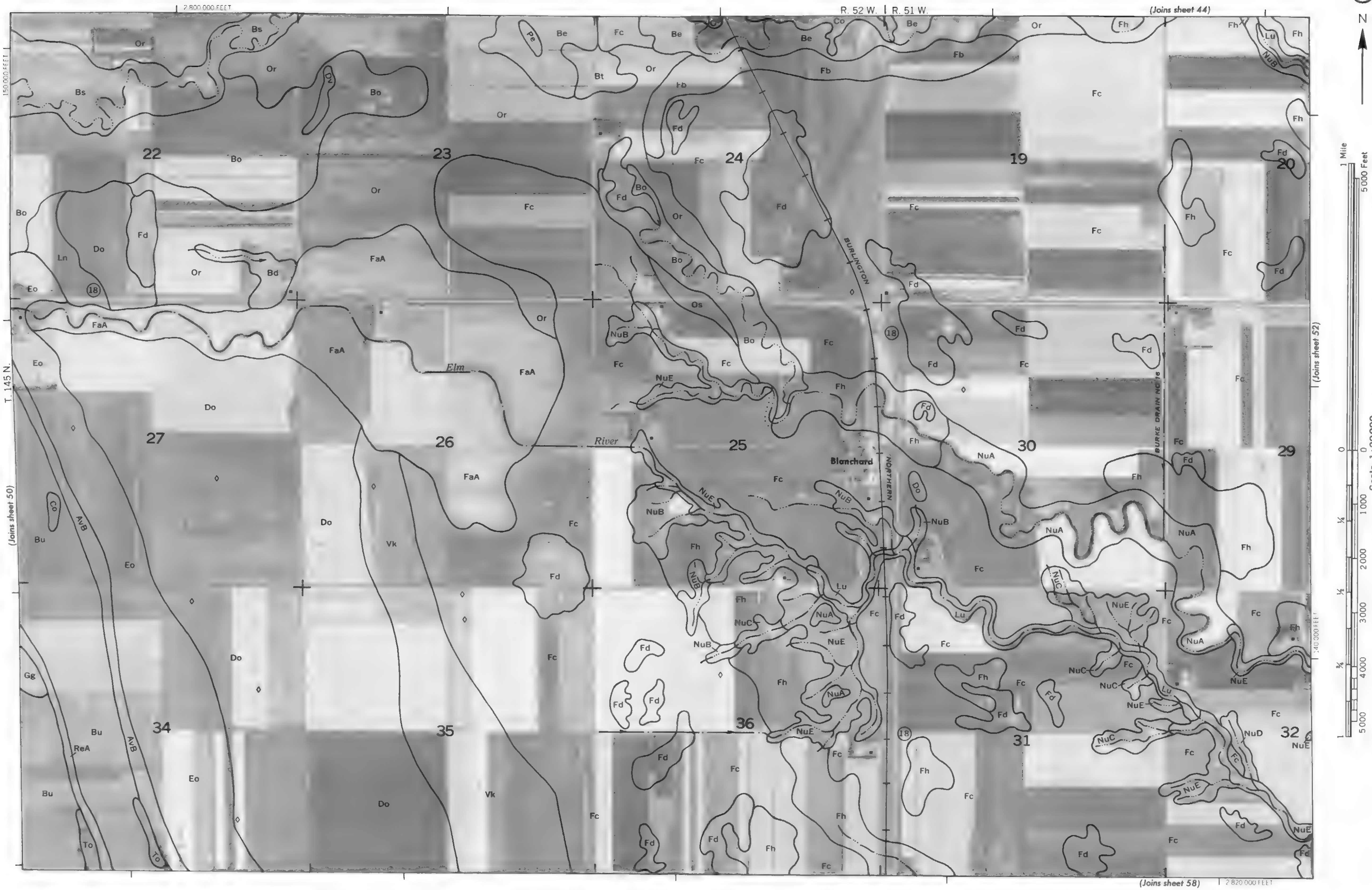
STEELE COUNTY

1 Mile 5000 Feet

Scale 1:20000

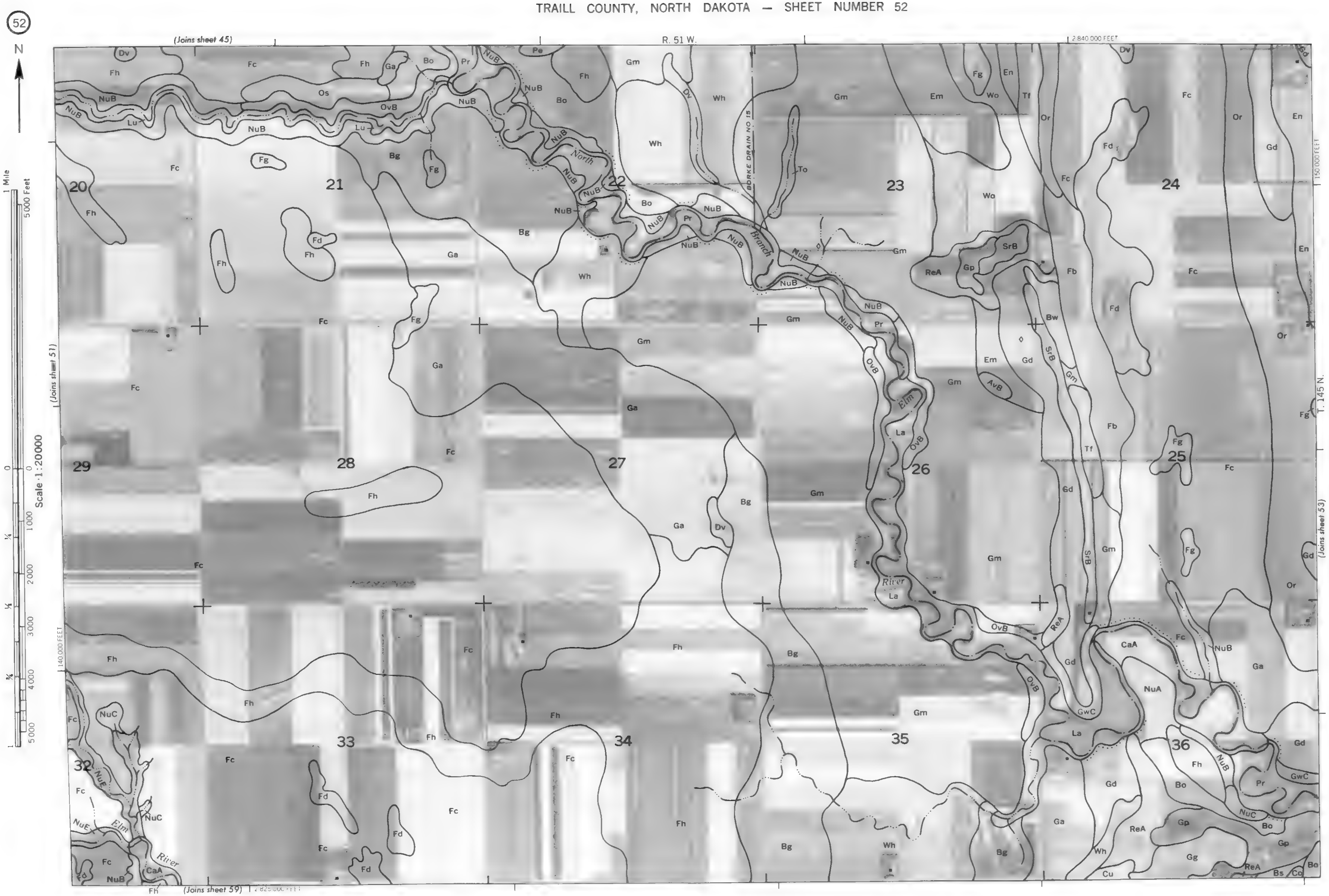


This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.



TRAILL COUNTY, NORTH DAKOTA NO. 51

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture Soil Conservation Service and cooperating agencies
Coordinate grid ticks and land division corners, if shown, are approximately positioned.



This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.

TRAILL COUNTY, NORTH DAKOTA NO. 53

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

54

N

(Joins sheet 47) R. 50 W. R. 49 W. 2 890 000 FEET

LEIRNESS DRAIN NO 34

NELSON DRAIN NO 28

NELSON DRAIN NO 28

T. 145 N.

150 000 FEET

(Joins sheet 53)

(Joins sheet 55)

140 000 FEET

2 870 000 FEET (Joins sheet 61)

Scale · 1 : 20000

1 Mile 5 000 Feet

0 0 1000 2000 3000 4000 5000

Hn NuA Be GwA Bn Go Gd Gm Fh Fc Ho

23 24 19 20 21 26 25 30 29 28 35 36 31 32 33

200

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies
Coordinate grid ticks and land division corners, if shown, are approximately positioned

TRAILL COUNTY, NORTH DAKOTA NO. 54

TRAILL COUNTY, NORTH DAKOTA NO. 55

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.

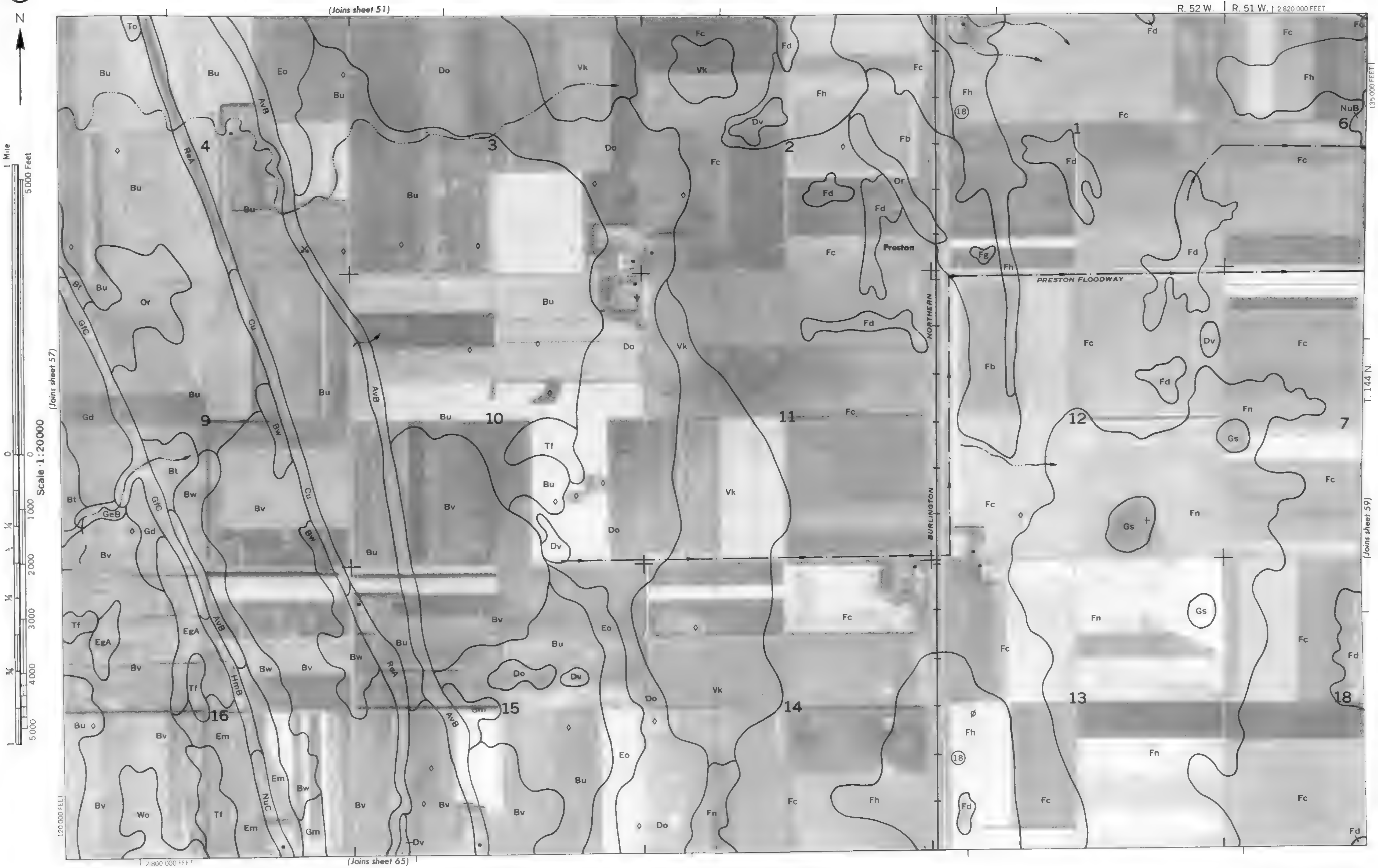
TRAILL COUNTY, NORTH DAKOTA — SHEET NUMBER 56

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.

TRAILL COUNTY, NORTH DAKOTA NO. 56

TRAILL COUNTY, NORTH DAKOTA NO. 57

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies
Coordinate grid ticks and land division corners, if shown, are approximately positioned



This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

TRAILL COUNTY, NORTH DAKOTA NO. 59

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture Soil Conservation Service and cooperating agencies.
Coordinate grid (cos and land division corners if shown, are approximately positioned.

2 825 000 FEET

R. 51 W.

(Joins sheet 52)

135 000 FEET

T. 144 N.

(Joins sheet 58)

(Joins sheet 60)

125 000 FEET

(Joins sheet 66)

2 845 000 FEET

N

1 Mile

5000 Feet

Scale 1:20000

60

N

(Joins sheet 53)

R. 51 W.

R. 50 W.

2 865 000 FEET

135 000 FEET

T. 144 N.

1 Mile

5 000 Feet

Scale · 1 : 20000

(Joins sheet 59)

125 000 FEET

(Joins sheet 67)

2 850 000 FEET

(Joins sheet 61)

Kelso

North Branch Elm River

BURLINGTON NORTHERN

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

Bo Or Fb Fc Fe Bt Pe Gd Fg Fh Hn CaA Cu Bn EdA

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned

TRAILL COUNTY, NORTH DAKOTA NO. 60

TRAILL COUNTY, NORTH DAKOTA NO. 61

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies
Coordinate grid ticks and land division corners, if shown, are approximately positioned

2 870 000 FEET

R. 50 W. | R. 49 W.

(Joins sheet 54)

T. 144 N.

135 000 FEET

(Joins sheet 60)

(Joins sheet 62)

125 000 FEET

(Joins sheet 68) | 2 890 000 FEET

61

N

1 Mile

5000 Feet

Scale 1:20000

Hn Fh Fc Ho Bn Dv Fd CaA NuA NuB NuC Fg

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

North Branch Elm River

62

N

(Joins sheet 55)

R. 49 W.

2 915 000 FEET

140 000 FEET

1 Mile

5 000 Feet

Scale · 1 : 20 000

T. 144 N.

(Joins sheet 61)

125 000 FEET

2 895 000 FEET

(Joins sheet 69)

Bn Hn Fc Fh Lu NuC NuA CaA CaC Ho NuA WaA Ed

4 3 2 9 10 11 16 15 14

RED RIVER OF THE NORTH

Elm River

NORMAN COUNTY, MINNESOTA

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners + shown are approximately positioned

TRAILL COUNTY, NORTH DAKOTA NO. 62

TRAILL COUNTY, NORTH DAKOTA NO. 63

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

64

N

(Joins sheet 57)

R. 53 W. | R. 52 W.

2 795 000 FEET

T. 144 N.

115 000 FEET

(Joins sheet 65)

(Joins sheet 63)

105 000 FEET

2 780 000 FEET

CASS COUNTY

1 Mile 5000 Feet

Scale 1:20000

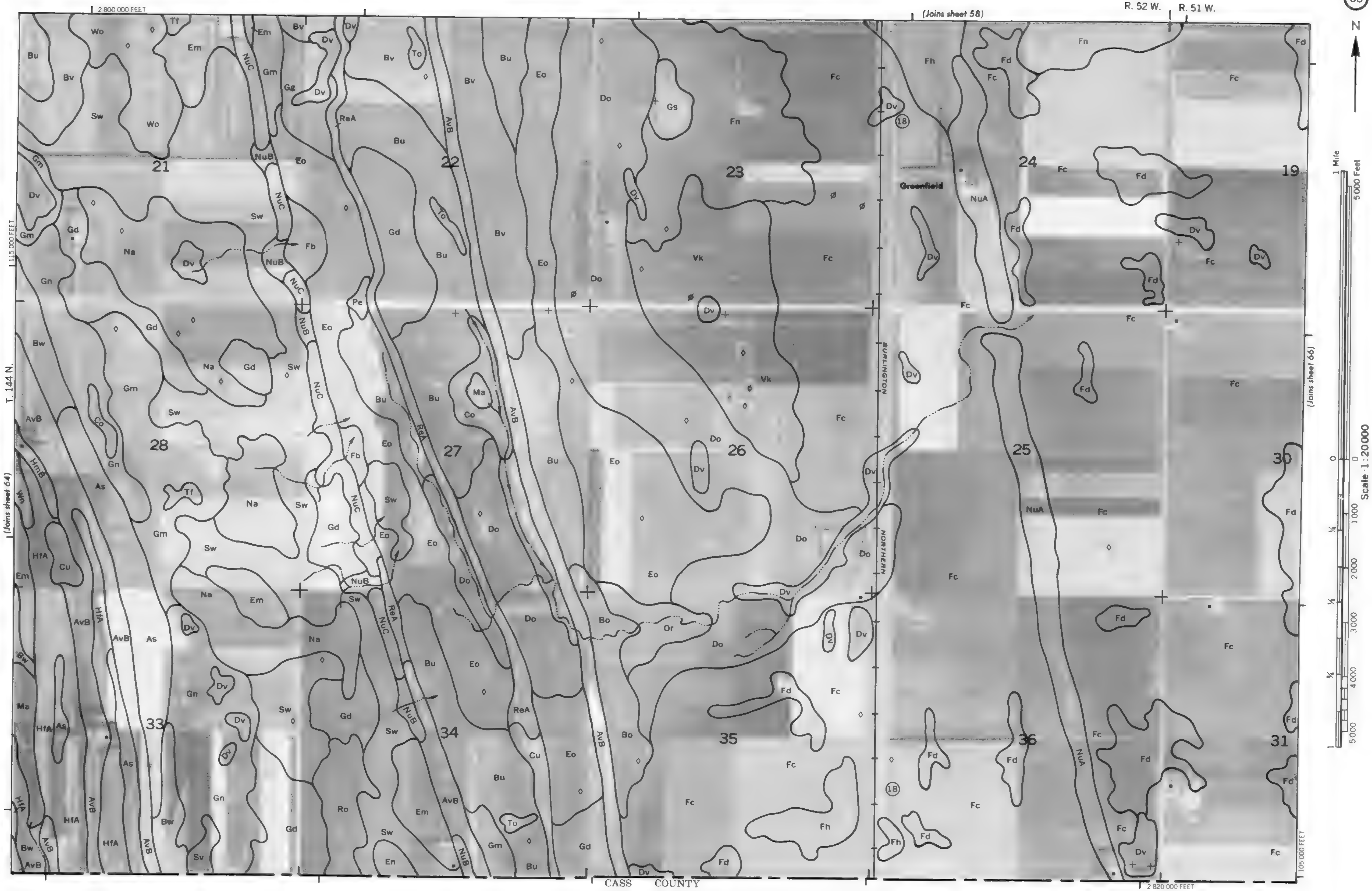
0 ¼ ½ ¾ 1

0 1000 2000 3000 4000 5000

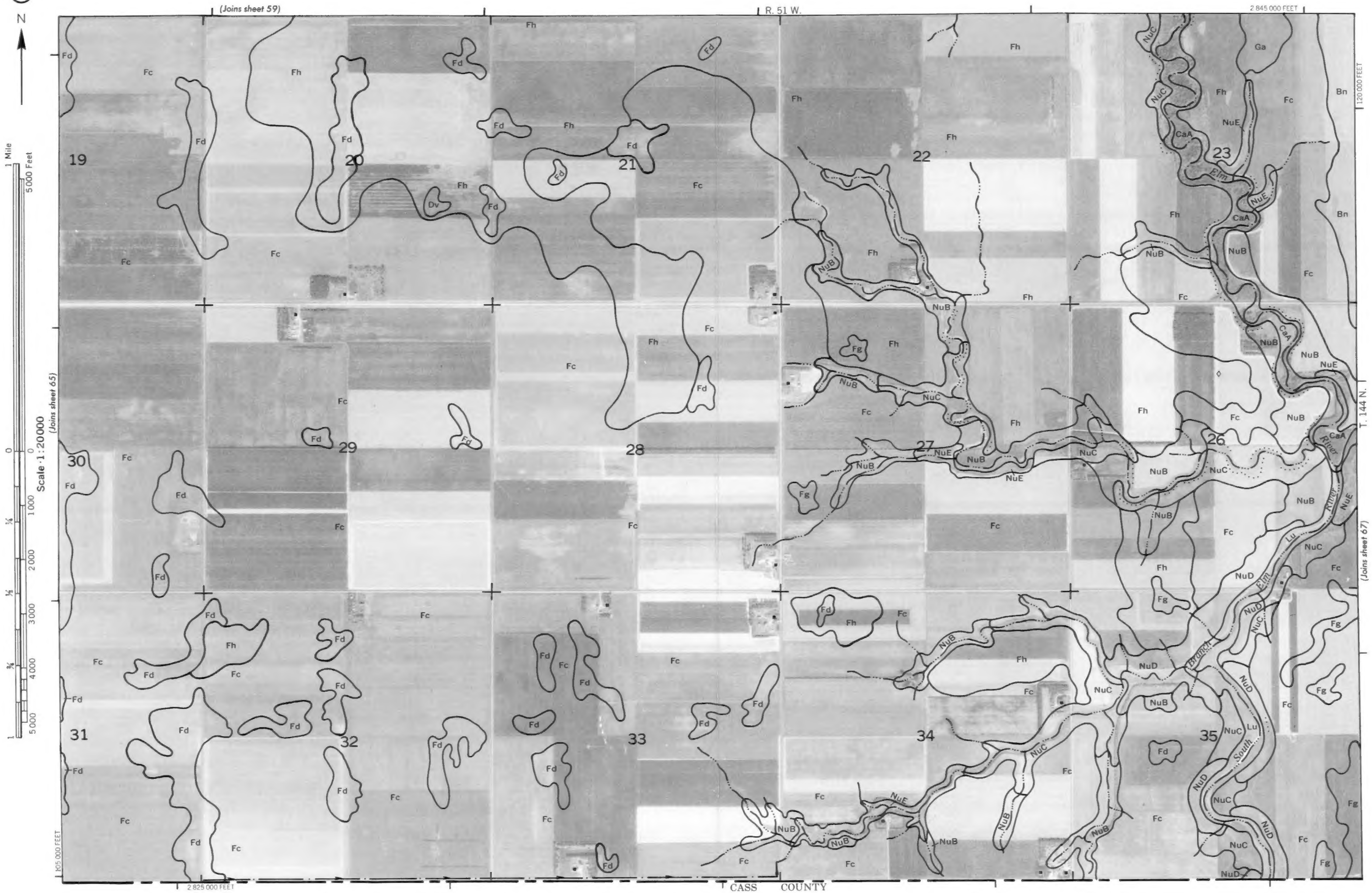
TRAILL COUNTY, NORTH DAKOTA NO. 64

TRAILL COUNTY, NORTH DAKOTA NO. 65

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.



TRAILL COUNTY, NORTH DAKOTA — SHEET NUMBER 66



This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

TRAILL COUNTY, NORTH DAKOTA NO. 67

This map is compiled on 1974 aerial photography by the U.S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.

67

N

2 850 000 FEET

R. 51 W. | R. 50 W.

120 000 FEET

(Joins sheet 60)

KELSO FLOODWAY

(Joins sheet 66)

T. 144 N.

(Joins sheet 68)

110 000 FEET

2 870 000 FEET

CASS COUNTY

BURLINGTON NORTHERN

Elm River

water

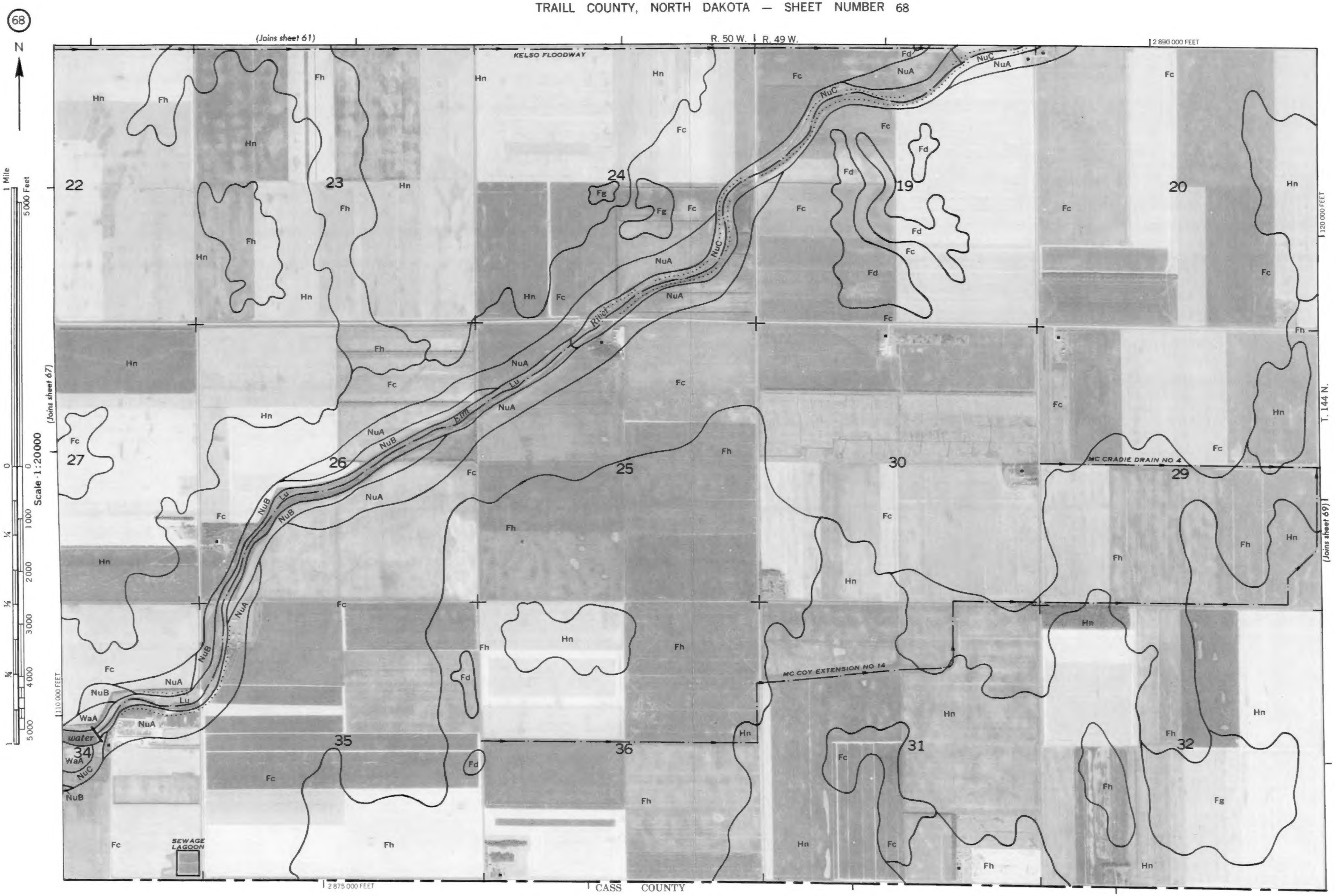
1 Mile

5 000 Feet

Scale 1:20000

0 ¼ ½ ¾ 1

0 1 000 2 000 3 000 4 000 5 000



This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.

TRAILL COUNTY, NORTH DAKOTA NO. 68

TRAILL COUNTY, NORTH DAKOTA NO. 69

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.

2 895 000 FEET

R. 49 W.

(Joins sheet 62)

120 000 FEET

T. 144 N.

(Joins sheet 68)

21 22 23 26 27 28 33 34 35

MC CRADIE DRAIN NO 4

RED RIVER OF THE NORTH

NORMAN COUNTY, MINNESOTA

Elm River

Fc Hn Ho Bn Fh Dv NuA NuB WaA CaA CaC

CASS COUNTY

2 915 000 FEET

110 000 FEET

69

N

1 Mile

5000 Feet

Scale 1:20000